CROSS TALK

▶**TELAUTO** . . . The question of the bandwidth required to transmit intelligence at a given rate is, to judge by its many appearances in this column, a subject on which we're hipped. At any event we were much taken by Bill Tuller's discourse on the weather map and the telautograph, given at a recent communication symposium in Washington. It is customary to transmit weather maps by facsimile, using the familiar line-at-a-time scanning process. But this system ignores the evident fact that the map of the United States stays reasonably constant from day to day. What changes is the position of the isobar contours and associated symbols. Recognizing this fact, we might send the basic map through the mails and employ a telautograph (the gadget commonly seen in stores, banks and railroad stations which transmits handwriting by an electrically-actuated pen) to transmit, handwriting-fashion, the contours and symbols. The facsimile scanning system needs a bandwidth of several hundred cycles. The telautograph, freed from the necessity of transmitting anything but the essential information superimposed on the map, needs a bandwidth of only 15 cycles to do the job at the same speed. Tuller's point is that a transmission system set up to take account of the special characteristics of the information to be transmitted may be much more efficient than one which ignores said characteristics.

A logical extension of this philosophy applies to television. The background of many television scenes remains unchanged for considerable periods, and need not be changed in less time than, say, a quarter of a second. Suppose then that the background could be transmitted separately from the central subject matter. If a storage screen were available to retain the background it could be transmitted at a slow rate, that is, in a narrow band. The major part of the video band might then be reserved for depicting the smaller area comprising the central subject of the scene and the detail of this subject would be correspondingly enhanced. The detail of the background, being sent at a slow rate, could readily be made to match the high value possessed by the central subject. This proposal is easily stated, much more difficult to achieve in practice, and its application is limited to scenes having separately delineated subjects and backgrounds. But in the long run it may prove to be a practical method of enhancing the detail of television images.

▶**BROAD** . . . Progress in the design of broadband amplifiers for television, radar and pulse communication is so rapid that, for a change, the engineers are ahead of the demand. When electronic television came along in the early thirties, the tubes of the day permitted amplifying a band no wider than a few megacycles. Then came radar; in 1945 it was news that an amplifier having a bandwidth of 20 megacycles had been achieved. Now comes a new technique, called "distributed amplification" or "wave amplification". Several tubes are used in each stage, the capacitance of each tube being isolated in a separate section of a filter. In this way the output currents of the tubes are added while their capacitances are separated, and a wholly new order of bandwidth becomes possible. In one such amplifier, a bandwidth of 200 mc. with 9-db gain, is achieved in an amplifier using seven 6AK5 tubes in a single stage. Further progress must, in all likelihood, wait until someone finds a use for what is now available.

It is indeed encouraging when the techniques thus outstrip the applications. It gives the system engineers something to think about: a 200-mc amplifier can transmit at one crack all the signals in the prewar frequency spectrum, all point-to-point, marine, mobile services, all standard broadcast, f-m, facsimile, all television, navigation, and amateur signals. Looked at another way, a 200-mc bandwidth can transmit messages at the rate of over a billion words per hour, or a ten word telegram once a day to every man, woman and child on earth. The amplifier exists. Any takers?

Here is an article that is definitely not technical. ELECTRONICS, a technical magazine, is nevertheless proud to present it.

The subject is important to everyone in every manufacturing industry. In a new and fast-changing industry like electronics, a continuing supply of new products is particularly essential. Here, however, as in so many other fields, the lifeline of idea-flow from research through production is being throttled at dozens of points.

The author tells what you can do about it in your own plant.

—THE EDITORS

Selling Research Ideas

An idea born of research is useless unless pushed and passed on by those who come after, right through production of the resulting new or better product. Idea promotion requires convincing facts, good research reports, working models, repeated follow-ups and frequent research-design-sales meetings

By WALDO H. KLIEVER

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THERE ARE THOSE who would say that after research people have done their work it is up to management or someone else to see that its results are used. That would be lovely if it would work. I well remember thinking, when starting out in the business of research, that when something good was developed there would be no doubt about anyone being interested in it. How innocent!

After working on a number of problems I found that while I could develop what appeared to be good workable devices to satisfy the problems that had been assigned to me, everything seemed to end at that point. I would show the working models and everyone would say "How nice" or "That's wonderful," but that was all.

Even the people who had asked for the developments had in the interim become interested in other things and were not inclined to do anything about it.

There I was as helpless as the distinguished visitor trying to make a phone call from the insane asylum. After failing sadly to get results, he said in desperation to the operator, "Do you know who I am?" and she sweetly replied, "No, but I know where you are."

Something had to be done. In talking with others and doing considerable reading on the subject, it became obvious that the problem was not unique with me. One man[1] confirms this as follows: "The research director's job, therefore, is not done when the product has been invented, designed, and proven in theory. He has to sell it, just as much as if he were a private inventor."

The Basic Problem

It is here that we bump into the thing called human nature. People are inclined to be interested in their own ideas; accepting someone else's ideas requires considerable effort, and there is also perhaps a little strain on individual pride. They have inertia; they don't want to be bothered. Whether it is for these or other reasons, it is generally conceded that one of the most difficult things in the world to sell is an idea.

And so we come face to face with the sales problem in research. Some people say this should be the function of top management. For this reason those who direct research are often included in top management or in meetings with management when decisions about new products are made. However, the director of research, the vice-president in charge of engineering, or someone in a similar position who is very close to the research work must still present the new ideas in such a way that they will appear sufficiently attractive financially and otherwise to promote the necessary interest. He must close the gap between the technical facts and their business significance.

The fact that any management maintains a research organization is evidence that it is interested in new ideas, but it is the right and duty of management to question

This paper was presented at the 1948 National Electronics Conference in Chicago.

Regular idea-evaluation meetings are one requirement for acceptance of good new ideas. In this typical Minneapolis-Honeywell research department meeting are, left to right: Glen Seidel, administrative engineer; Raymond O. Anderson, coordinator of research; Waldo H. Kliever, director of research; John E. Haines, vice-president; John W. Magoffin, market research department; George Muschamp, vice-president in charge of engineering of Brown Instrument Division

these ideas and to require proof that they are economically sound.

In looking for solutions to this research-sales problem, one must go all the way back to the origin of the ideas. An idea originally suggested by those who will have to carry on with its future—an idea that fills a real need that is appreciated by everyone—will be accepted much more readily than an idea which enters a completely new field or replaces devices that have not been a source of extensive troubles.

New ideas may come from the customer, the sales department, management, the design engineering department, the research department, as by-products of work on other problems in research, and from inventors outside of the engineering and research departments.

It is helpful later, when the results of a project are considered for production, if those concerned with passing on it at that time are in at the early stages, provided not too much is promised at that time. However, the research department should have the right to carry on some investigations, especially those of a preliminary survey nature, without requiring extensive outside approval. Then, as the idea progresses, it should be reviewed more carefully in the light of technical feasibility, cost and marketability. Ideas that prove unpromising should be eliminated as early as a reliable decision can be made.

The complete path of a good idea may be as follows: (1) Basic research; (2) applied research or development; (3) design engineering; (4) engineering test; (5) methods engineering; (6) production; (7) sales. That is a long and devious route involving many different people, and it is not surprising that it involves transfer problems.

Attitudes to be Recognized

Even the basic attitudes of various groups toward problems will differ. For example, in basic research the objective is information, while in applied research the objective is new products. Companies differ widely in the amount of basic research they do. Ideas often originate from basic research done in other organizations, including universities. Many companies sponsor basic research in universities or research foundations.

Basic research is very important, but this present study will be more concerned with selling the products of applied research. Applied research has been described[2] as follows: *"The pursuit of a planned program toward a definite practical objective—a preconceived end-result. It takes the results of fundamental or exploratory research and tries to apply them to a specific process, material, or device."*

In the design engineering group the objective is still new products, but with more thought to how the new product can be manufactured and made to work reliably under field conditions. The research man is an optimist who takes ideas that everyone says are impossible of execution and shows how they can be made to work. The design engineer is a pessimist who takes ideas

Research reports should be attractive and styled for easy reading. This means double-spaced typing, liberal use of subheads and a convenient table of contents as in this annual report. Note use of special printed stationery and spiral binding

that everyone feels are ready for production and finds the bugs which might cause later serious difficulties. This division of responsibilities has been defined[3] as follows: *"The research man, if he is to be worth anything, must be able to find the grain of gold in the pan of gravel; the development engineer must be able to see the fly in the ointment. These attitudes—the one trained to look for what's wrong, the other to see the valuable features of a complete failure—make engineering and research complementary to each other, but also miles apart."*

What about the attitude of the sales people toward new developments? They will want to know what the device does for the customer and how it compares with competition in performance and price. Don't bother them with telling how it works or how it is made.

For convincing management of the worth of the idea, dollar signs must be used, along with other pertinent information.

This diversity of methods of approach is necessary in the selling of research ideas. Know your people. Quoting again,[1] *"There is no part of research more important than sales, and this means, in order of increasing importance, a good article, proper preparation of sales presentation, full knowledge of the financial situation of your customer, knowledge of the peculiarities of the personality of those to whom you sell, and most of all, personal contacts."*

Transferring Ideas

Having reviewed a research project after preliminary survey, with due regard for marketability of the end products, the project people in applied research proceed with the serious business of producing the best solutions to the problem. Here we must be careful, in our zeal for results, not to restrict the necessary freedom of the people in research.

In general, the research departments will not come up with the kind of device expected; if they do, it is probably a sign that the research was not very thorough. Also, if the research department is alert there may be several possible by-products from the investigation which often are more important than the original objective. The freedom in applied research, however, is always tempered by the feeling that research is a serious responsibility and that there are general objectives to be kept in mind.

Another characteristic of good research people must be considered. A good research man will always see additional ways to make improvements on ideas and he will insist that he should have a little more time to study this or that, until the development goes on and on without end. When to transfer an idea from research into production design probably constitutes one of the most important problems in research management. Expressed another way, it is the problem of determining the state of perfection which should be required before transfer to the development team.

One procedure is to let the research man continue in his endless quest, with the director of research or the company management reviewing the work periodically. When any development has progressed to a point where it offers sufficient improvement over equipment in current use or in a new field to justify it, and when the device developed appears to be workable and saleable, the available information is extracted from research for conversion into production. We do not wait for the final perfect design, but often allow the research to continue on the same problem so that in one or two years we can obtain from it further improvements in products. It is much easier to justify spending money on further work on a project after it is bringing returns.

Requirements for Selling

When the director of research has selected an item to be considered for production he faces the two-fold problem of convincing management and sales that the new product should be manufactured and informing and convincing the production design engineering people that the work done in research is a good basis for the design of a product.

In the sale of research products,

as with other sales work, certain aids are essential:

(1) *Basic facts.* This is the most important requirement on the list. It includes not only information about what the device is and what it can do, including test results, but in the final form will also have to include a market analysis, along with cost estimates for manufacture and for design and tooling. The research department may or may not be responsible for the latter, but must certainly be interested to see that such information is available.

(2) *Research reports.* These should include illustrations, diagrams and complete well-organized information and technical data. Reports are also a useful adjunct to laboratory records, especially in connection with projects not contemplated for immediate production, and they help to clarify the thinking of the research people who write them. It is worth while to make these reports attractive and styled for easy reading. We have a business manager in the research department who makes it his business to see that the reports are written and are complete and comprehensible.

(3) *Models.* We strongly believe in making up working models because they help to convince skeptical people, especially the design engineers, that something usable is being presented, and make the idea more interesting and understandable. Models also help the research people, in that they give the concrete objective of producing a working model.

(4) *Meetings.* Most people are overburdened these days with conferences and meetings, but there still is a useful place for them. We believe that in getting together the interested parties and discussing a new product when it leaves research much can be gained. Many questions will be answered and mutual interest stimulated. The meeting may also point up channels for further research which are required or worthwhile.

(5) *Field applications.* The research department will usually be called upon to try out the idea on various problems in the field. Some of this type of work is good for the education of research people, for better knowledge of the product and for promoting confidence in the research work. In general, much of this application work in research should be avoided because it can easily grow to demand a considerable part of research time. Besides, it provides a good means of acquainting the production design engineering department with the problem if the application work can be done there.

One thought which must permeate all of the above sales methods is "Be specific". If possible, do not propose three ways for solving a problem and leave it to someone else to make the choice. The research department can generally inform themselves sufficiently well to be in the best position for recommending a definite solution. If research has not progressed to this point, it is better to study the matter further before making the sales presentation. This principle is probably not much different here than it is in any sales work.

Follow-Up

Having presented a new idea and obtained approval for production design, along with work priority assignments by the sales department and the design department where necessary, one could easily feel that now the research department can forget the matter. Such is far from being true. In most cases the matter would die quickly if so neglected, or in any case would take routes which have been shown in research to be blind alleys.

Nobody Likes a Change

"The greatest durability contest in the world is getting a new idea into any factory. It is well if the management understands this and will constitute itself the sales department for the research organization. Otherwise, the hard-boiled men in the factory will put research men out of business in a fortnight.

"When we present a new idea to people, their first instinctive reaction is against it. Nobody likes a change. That is the one great thing you must understand in the psychology of research."—Charles F. Kettering

It is never possible to put all the information learned in research on paper. Experience has shown that a close collaboration and follow-up is needed for a long time after the transfer of an item from research to design. However, during this period the research department will have to be tolerant of changes in the ideas and in the device. Designers are creative workers also and will contribute ideas of their own. If this is not permitted, life becomes uninteresting and unpleasant for them and you wouldn't want that to happen. Unless research people have good reasons to argue with designers that one of the design proposals will lead to trouble, such modifications should be allowed. In general, the changes will be for the better. Incorporating many people's ideas into a product seems to lead to the best end result.

This brings us to some general considerations in the relationship of research with other departments in the company. The marketing of product ideas becomes much easier if the research department is well acquainted with the problems of salesmen, the problems of designers, the problems of field sales people and the problems of management. This might be called personnel relations work by research. It involves a helpful attitude toward other people's problems, rather than competition with these people. It involves instilling in contacts with others a feeling of confidence, rather than a spirit of jealousy or excessive pride.

If these interdepartmental contacts are properly handled, the research department and the director of research will find that others in the company are regularly coming to them with problems. Such contact is not only a helpful condition in guiding research work, but the spirit of it is a necessity for bringing research to that successful goal which includes actual products going out to benefit humanity.

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(1) J. R. Bichowsky, Industrial Research, Chemical Publishing Co., New York, N. Y., p 56-57.
(2) C. C. Furnas, Research in Industry, The Macmillan Co., New York, N. Y., p 7.
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TELEVISION STATION COSTS

Plans are suggested for a small station to which additional plant and facilities can be added in normal process of growth. Building costs are estimated and figures are given for equipment, beginning with bare essentials. Details show how to realize a maximum return for the investment

By WILLIAM FOSS
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THE installation and operation of a well-equipped television station today runs into astronomical figures when compared with the cost of construction and operation of standard broadcasting stations. In the early twenties there were many stations actually put on the air for sums so ridiculously low as to seem unbelievable. The writer actually constructed several such stations at costs under $10,000, this expenditure being the maximum sum that the owners invested. These same stations and many others like them are now operating successfully, are affiliated with national networks, and have in many instances brought returns to their owners in sums of seven figures.

The television story is entirely different. Construction costs can not be met for less than $100,000 and this sum represents a station such as a small town community could support. This size station would be limited by its incomplete equipment to very few hours of service per week and would probably have no studio. It would depend on mobile pickup equipment to televise sports and civic events, with possible additional programs from networks that are now fast growing, and from the projection of films.

In the design of suitable studio and projection facilities for television stations we face problems far more complicated and considerably more costly than those at standard broadcast stations. It is not unusual for a broadcast station to be able to find any number of buildings in average cities that can be made to accommodate the working force and supply studio space without the removal of a single partition. In television broadcasting, however, it is usually necessary either to build a new structure from the ground up or to perform a major operation in

Table I—Initial Studio Equipment Costs

Remote Equipment		
2 Camera chains complete	$32,750	
1 Standard pickup truck	11,000	
1 Auxiliary power supply	2,000	
Audio equipment and spares	4,000	
		$49,750
Studio lighting equipment	3,500	
		3,500
Projection room, consisting of 2 film camera channels with controls complete, 2—16 mm projectors, 1 slide projector, and 1 special picture projector		
Equipment	29,303	
Installation	2,500	
		31,803
Total		$85,053

Table II—Costs Including Control Equipment

Remote equipment		$49,750
Projection room		31,803
Studio lighting		3,500
Control room—1 program console, 1 master monitor, 1 line monitor, synchronizing, pulse and blanking equipment, power supplies and miscellaneous		
Equipment	$32,000	
Installation	5,000	
		37,000
Total		$122,053

Complete 500-watt television transmitter and control console

the remodeling of an existing building at a cost which is comparatively high.

High Ceiling Necessary

The reason that remodeling a building for studio facilities is usually necessary lies in the fact that the ceiling must be high enough to provide room for a special lighting system which, of course, is not necessary in standard broadcast work. Since a television station consists of two complete and separate transmitters, namely, one for the transmission of the picture (the so-called video plant) and the other a conventional f-m plant, it is also necessary to treat the studio to obtain the proper acoustic effects.

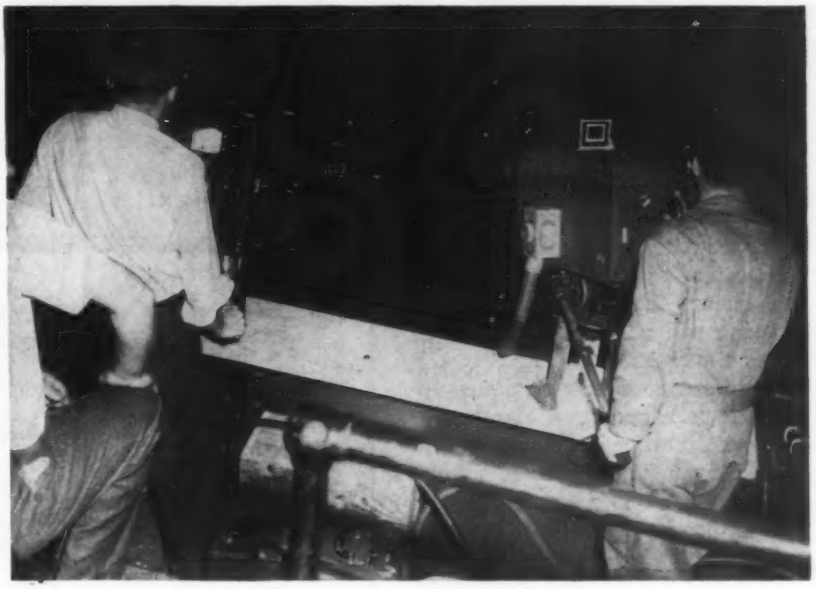
The trend at present seems to indicate that television studios will not be built to accommodate large crowds of spectators since the emphasis is on the pictures being transmitted and these can be seen on adequate monitors or on outside television receivers. The arrangement is advantageous from the financial standpoint because it eliminates the necessity of supplying a finished show place to the public. This article will not attempt to supply in accurate detail either the finished plans of studios or the exact costs to be met. It is, rather, the intention of the writer to present such plans and costs in general that will stimulate in the mind of the reader ideas necessary to develop concrete plans that fit each individual case.

Tables of costs for equipment alone which will be supplied hereafter indicate the importance of designing in order to make every possible piece of equipment carry its share of the financial load. From these tables it will be noted that a properly equipped pickup truck will cost in excess of $49,000. If, for instance, a station is able initially to use the equipment in the truck both for the televising of remote events and for live programs at the studio location, a considerable saving can be made by designing a building so that the truck can be backed up to the studio and the equipment used in the studio with the truck functioning as the control room.

Truck Studio Control

Figure 1 shows such a plan. This plan represents a building so arranged that the shop on the first floor (A) can be used as a garage for the truck, in addition to functioning as a scene dock for props and scenery and a repair shop for general repair and maintenance work. It will also accommodate the truck when used as a control room, the truck being backed up to a large window in the studio when so used. The minimum investment necessary to give continuous service will be that necessary to equip a truck for handling remote programs and for equipping a projection room where films, slides, and other pictures can be televised.

The investment just mentioned



Typical night baseball pickup. Note that remote cameras are semi-permanently mounted on parapet

Table III—Equipment Costs with Studio and Control

Remote equipment		$49,750
Projection room		31,803
Control room		37,000
Studio		
Video and audio equipment	$32,895	
Lighting	3,500	
Treatment	5,000	
Installation	4,000	
		45,395
Total		$163,948

does not include the transmitter, antenna, and their associated apparatus nor does it include a master control room where the dispatching, distribution, and main control of the program can be centralized. The transmitters and antennas will be discussed later. In lieu of this control room, simple switching devices may be designed and operated at the transmitter location, or they may be installed at the projection room location.

Table I indicates the equipment costs for the plan shown in Fig. 1, showing the projection room and truck but not including the control room and not including the transmitter and its related equipment.

Figure 1B shows the second floor plan of the same building. The film projection room is so designed that when the studio is to be equipped with its own apparatus a control room then can be built in. In case the whole operation is a consolidated one, the transmitter may also be installed in this presently available space.

Table II also indicates equipment costs for the plan shown in Fig. 1. In this instance the control room is equipped to dispatch and coordinate the operation of the remote equipment, the projection room, and network terminal facilities. However, the cost of equipping the studio is not shown in this table. Studio lighting will be necessary provided a room such as shown in Fig. 1 is used in conjunction with the equipment from a truck. A rough estimate of lighting costs may be obtained by using the cost figures $4.00 to $4.50 per square foot of studio floor space. A pipe-work grid should be installed on the ceiling for the purpose of hanging the overhead fixtures. This grid should be made up in squares, each grid not larger than seven feet.

Table III indicates equipment costs for the plan shown in Fig. 1 when the studio is so equipped as to operate from the control room, permitting the use of the remote equipment purely for pickup.

The main drawback with the first plan above described lies in the fact that when the station first goes into operation, the mobile equipment is tied up whenever a live program from the studio is necessary. A further drawback becomes immediately evident when the first studio is equipped. While the building of control equipment into the studio does free the mobile equipment to pick up programs for which it was primarily designed, station operators are still faced with a further serious drawback. This lies in the fact that adjacent or contiguous live

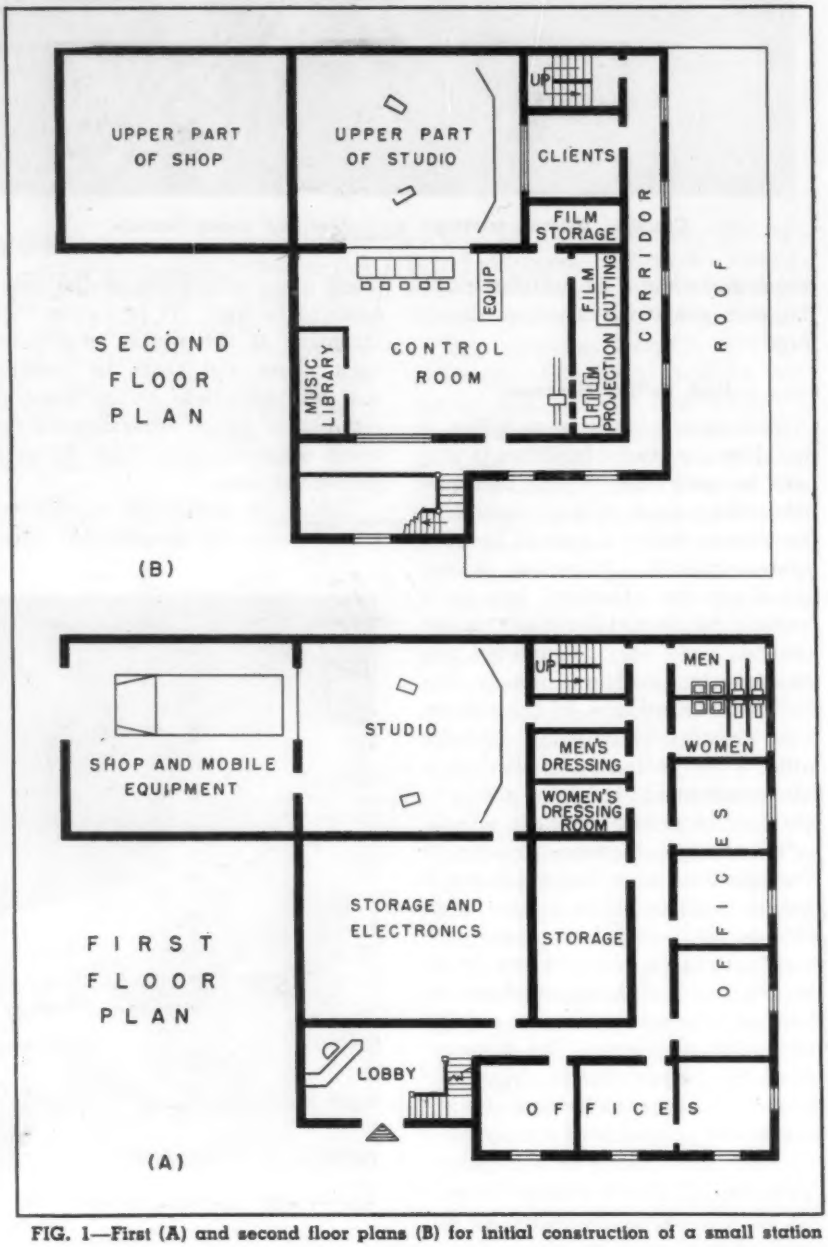


FIG. 1—First (A) and second floor plans (B) for initial construction of a small station

programs cannot be put on from the studio and it will therefore be necessary either to broadcast programs from the projection room or from the mobile equipment while studio scenery is being changed. If the studio is large enough to accommodate more than one scene at a time, the scene may be set up before the series of broadcasts starts and the cameras and associated apparatus may be moved to pick up each scene in succession. However, no scenes can be changed while the studio is on the air because of the noise caused in making such changes.

Figure 2A shows a first floor plan for the expansion of the same building to accommodate two studios and Fig. 2B shows the second floor plan of this enlarged building. In this plan two completely equipped studios with a master control have been provided in addition to the projection room which is necessary for the station operation from the start. In addition, the shop has been increased in size to accommodate props and scenery to be used in the two studios. The turntable shown installed in Studio A will be discussed separately.

Table IV indicates equipment costs for the plan shown in Fig. 2.

Referring to the total cost as shown in Table III, it is seen that the cost of equipping a second studio will be an additional $45,395 or a total of $209,343. This additional investment will furnish a second studio and give the station the necessary flexibility which will

Table IV—Equipment Costs for Plan in Fig. 2

Remote equipment	$49,750
Projection room	31,803
Control room	37,000
Studio A	45,395
Studio B	45,395
Total	$209,343

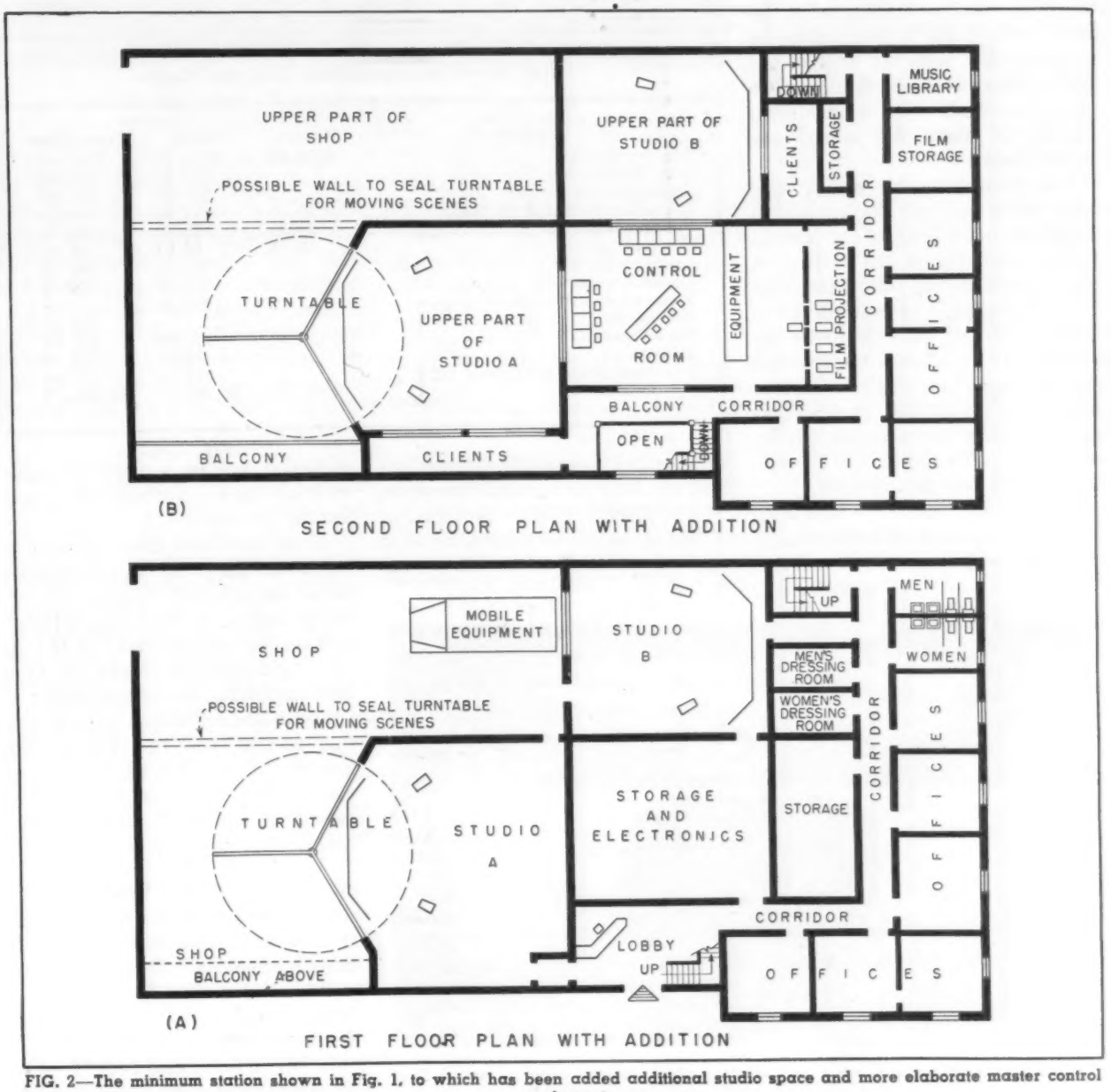


FIG. 2—The minimum station shown in Fig. 1, to which has been added additional studio space and more elaborate master control equipment

finally be needed to carry on continuous live programs.

The turntable mentioned above and indicated in Fig. 2 is important to this discussion for two reasons, —first, to create a substantial saving when one studio alone is used; and second, to add additional flexibility resulting in increased facility in the station operation.

The cost of such a table when electrically driven varies from approximately $8,000 for a table 25 feet in diameter to approximately $11,000 for a 40-foot table. The wings or partitions segregating the table into three parts may be swung to vary the size of the settings or may be completely removed from the table when a rotating set is desired. The table is planned to be mounted flush with the floor of the studio and so designed that it can be loaded unevenly with a maximum loading of about 50 pounds per square foot.

This plan calls for a shop and scene dock behind the studio in which the main body of the table is located so that work can be done on the sets on the shop side of the table while televising is proceeding in the studio. If the table is to be installed in the studio before the second studio is built, a certain amount of flexibility can be expected with a construction saving of from $30,000 to $40,000, depending upon the size of the table.

Most manufacturers currently design and construct transmitters of only two sizes, namely the 500-w or so-called community transmitter and the 5-kw or metropolitan type. The transmitter may be installed either at the site of the studios or at a remote location which affords the radiation system a more favorable location for the purposes of propagating the wave.

Table V—Transmitting Station Costs

	500-W Transmitter		5,000-W Transmitter	
	Channels 2–6	Channels 7–13	Channels 2–6	Channels 7–13
Transmitter	26,500	34,000	82,165	88,200
Spare tubes and parts	3,000	4,000	8,045	9,288
Aural monitor	1,600	2,000	1,980	2,000
Visual frequency monitor	675	675	675	675
Picture demodulator	650	650	650	650
Waveform demodulator	900	900	900	900
Power supply	365	365	365	365
Adapter kits	20	20	20	20
Rack cabinet	390	390	390	390
Antenna	12,000	13,000	12,000	13,000
Tower, 100 ft	2,000	2,000	2,000	2,000
Transmission line, 2 lines 150 ft	500	500	2,000	2,000
Transmitter house	3,500	3,500	7,500	7,500
Tower lighting	800	800	800	800
Labor	8,000	8,000	12,000	12,000
Total	60,900	70,800	131,490	139,788
Contingencies 10%	6,090	7,080	13,149	13,979
Grand total	66,990	77,880	144,639	153,767

Table VI—Test Equipment List and Costs

Equipment	Remote	Studio	Transmitter
5-in. oscilloscope	$195.00	$195.00	$195.00
3-in. oscilloscope	.....	550.00	550.00
Square-wave generator	.....	225.00	225.00
Capacitance—resistance bridge	59.50	59.50	59.50
Voltohmeter	39.50	39.50	39.50
H-v multiplier	18.75	18.75	18.75
Audio oscillator	.....	500.00	500.00
Distortion and noise analyzer	.....	575.00	575.00
Video sweep generator	.....	1,000.00	.....
Wavemeter	.....	.....	38.00
V-t voltmeter	150.00	150.00	150.00
Tube tester	.....	59.50	59.50
5-in. oscilloscope (Tektronix type)	.....	795.00	795.00
Total	$462.75	$4,167.25	$3,205.25

Typical small-studio control room with audio controls at left, video at right. The program director sits at the desk

Since television channels are located in the very-high-frequency band, the radiated signal is subject to shadowing by obstacles between transmitter and receiver. It is usually necessary, therefore, to take into consideration the possibility of shadows and reflections when selecting a site for the transmitter proper. Simply stated, if you can see it, you can hear it, although service may be rendered beyond the line of sight under some conditions.

Transmitter Costs

In Table V the costs of the transmitters and associated equipment have been set up. This table is approximately correct except that no consideration for the cost of land has been given.

It will be noted that both types of transmitters designed for channels

Mobile field unit that can double as initial control room for the small station. One camera and 7,000-mc relay equipment are mounted on the roof

2 to 6 are less expensive than those designed for channels 7 to 13. Since the band including channels 2 and 6 represents frequencies from 54 to 88 mc and the band including channels 7 to 13 includes frequencies from 174 to 216 mc it is evident that tube design as well as transmitter design and construction is more expensive at the higher frequencies.

Relay Links

Where the transmitter and studio are situated at remote locations and also in cases where the remote equipment is functioning at sites away from the studio, it is present general practice to connect these units with relay circuits. Equipment has been developed and is operating successfully on several microwave channels. Notable in this category are circuits on approximately 2,000, 4,000, and 7,000 mc.

Since the equipment constructed for the higher frequencies can be manufactured in more compact fashion its high degree of portability renders it best for remote pickup work. The 7,000-mc equipment is therefore most popular to serve as a truck-to-studio link while in many instances the lower frequencies have been used between studio and transmitter. For the purposes of this paper, an approximate price of $10,000 for each complete link, consisting of a transmitter at the originating point and a receiver at the incoming terminal, has been used.

Testing Equipment

A certain amount of test equipment with every television installation is an actual must. Operating crews cannot be expected to maintain the apparatus nor can they do the necessary trouble shooting without an adequate complement of this equipment. As stated above, the transmitter is often located at a different site from the studio and the remote equipment needs maintenance and repairs when in the operating location. Table VI lists equipment of this type.

The foregoing indicates the approximate equipment costs that a prospective television station builder may expect to meet but does not include the price of real property either at the studio or that necessary on which to construct the transmitter. It has been estimated, however, that the cost of constructing a building such as that shown in the plans illustrated above will be in the neighborhood of $66,000 for the first stage of construction and an additional $59,000 for the finished building.

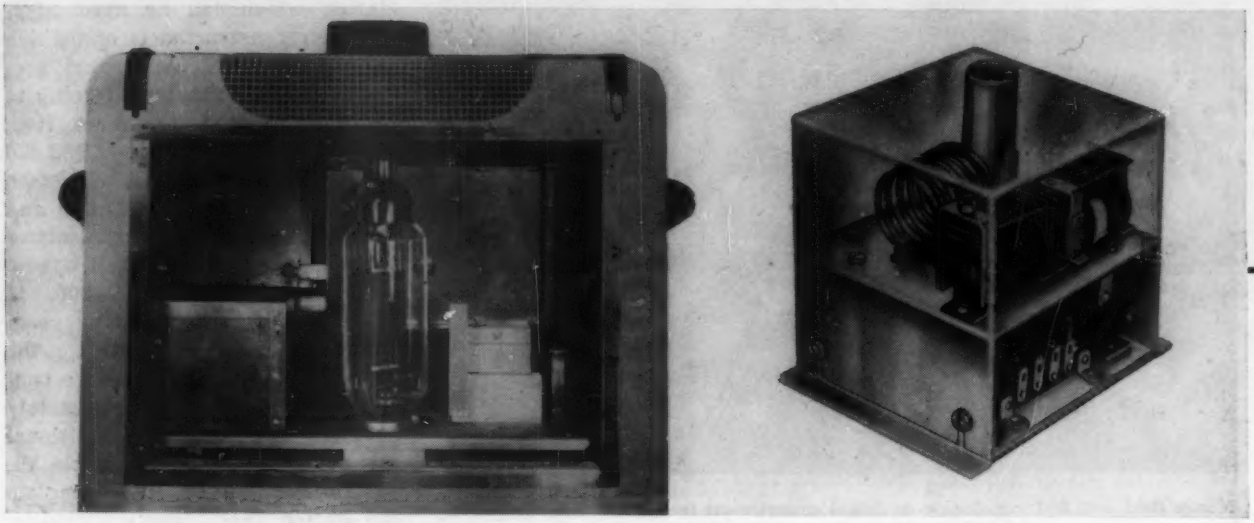
The approximate costs have been so tabulated, however, that any combination of equipments can be correlated and the resulting costs obtained from the tables. For instance, it is evident that the type of station which can be most inexpensively constructed is one which is equipped to receive network programs only. Thus, by referring to Table II, the control-room item shows an equipment cost of $32,000 with an installation cost of $5,000, bringing the total to $37,000 and from Table V a 500-w transmitter operating on channels 2, 3, 4, 5, or 6 will cost approximately $66,900. If the transmitter and control room are located in the same building, the owner should then be able to construct a station for approximately $103,990 and with the additional test equipment shown in Table VI, an additional $3,205 will complete the station.

If, however, the prospective owner is considering a well-equipped station with two studios, projection room and remote equipment, Table IV furnishes figures showing a total cost of $209,343. Table V for a 5-kw transmitter operating on channels 7, 8, 9, 10, 11, 12, or 13 shows a total of $153,767. Such a station will probably be so constructed that the transmitter and studios at different locations and the remote equipment will be supplied with radio relay links, two such circuits costing approximately $20,000.

In addition to the items stated above, test equipment in the amount of approximately $7,500 will be needed, bringing the total expenditure for equipment installed to approximately $390,610. Some few organizations have already gone well beyond this amount in constructing stations but in this paper it has been the intention of the writer to point the way for the beginning of such an operation in a comparatively modest way rather than to describe the more elaborate procedures of the larger companies.

The writer wishes to thank the personnel of the following organizations for their assistance in compiling the data herein: Radio Corp. of America, General Electric Co. Allen B. DuMont Labs., Inc., Television Associates and Lester V. Johnson Associates.

Frequency Stabilization



Rear view of Liebel-Flarsheim model SW-227 short-wave diathermy unit having FCC type approval. Single tube minimizes maintenance problems. At lower left of tube is plug-in monitor unit

Phantom view of Wavemaster monitor unit, showing differential relay and coil of resonant circuit

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PRIOR to the establishment of frequency allocations for short-wave diathermy units, frequencies anywhere in the range from about 10 to 60 mc were used by various manufacturers, depending on the type of applicator furnished. Since the therapeutic benefit is due to heat alone, all frequencies are equally effective in the treatment of tissue.

To suppress wasteful use of the frequency spectrum, three bands were assigned by the FCC for medical apparatus, in conformance with those adopted by the International Radiocommunications Conference, as follows:

Band	*Center Freq.*	*Tolerance*
13.5532-13.5667 mc	13.56 mc	6.75 kc
26.9573-27.2827 mc	27.12 mc	162.7 kc
40.6597-40.7003 mc	40.68 mc	20.3 kc

Although there is no limit to the amount of radiation permitted within these bands, harmonic radiation must not exceed 25 microvolts per meter at 1,000 feet.

The 13.56-mc band serves adequately for pads and inductive applicators, but is generally unsatisfactory for air-spaced plate applicators because the associated high reactance requires excessive patient-circuit voltages. The 27.12-mc band effectively operates all known types of applicators. The 40.68-mc band is usually unsatisfactory for inductive applicators because of excessive turn-to-turn voltages and resulting high dielectric loss, but is satisfactory for pads and spaced plates.

The wider frequency tolerance of the 27.12-mc band permits the design of simple self-excited oscillator circuits, obviating the complications and maintenance problems involved in crystal-controlled circuits.

Frequency-Shift Problems

The frequency stability of a self-excited diathermy oscillator circuit is affected by five major factors: (1) mechanical vibration or displacement of frequency-determining parts and components; (2) replacement of tubes; (3) replacement of parts; (4) frequency drift due to heating of oscillator circuit components; (5) frequency shifts due to patient-circuit loading and tuning.

Mechanical factors can be eliminated by building strong and sturdy circuit components and fastening them rigidly.

Changes due to tube replacement can be minimized by using a high tank capacitance so that variations in tube interelectrode capacitance will produce only small frequency changes. Here a limit is quickly reached due to the inefficiency of high-Q tank circuits, hence under the best practical conditions it is reasonable to expect up to a 50-kc shift in either direction due to interchange of tubes of identical make. When tubes of different manufacturers are interchanged, at least three times this shift is sometimes experienced.

Frequency shifts due to circuit heating can run as high as 150 kc, but by proper design this can be limited to 20 kc.

Patient-circuit loading is the bugaboo of all short-wave diathermy design. Applicator and patient-circuit impedances may range from 5 ohms to 150 ohms of resistance and from $+j2{,}000$ ohms to $-j2{,}000$ ohms of reactance. Variable coupling is therefore necessary to couple a patient circuit efficiently to an oscillator. A coupling for a

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# of Diathermy Units

Analysis of problems involved in building medical diathermy units that stay in FCC-allocated frequency band despite movements of patient or replacement of tube, and design of plug-in monitor that stops oscillator and sounds a buzzer when frequency drifts beyond predetermined acceptable limits for any reason

5-ohm load will not transfer enough power for higher-resistance loads; on the other hand, if the coupling is set for the high-resistance load and a low-resistance load is connected, frequency shifts will occur.

Example of Suitable Design

The short-wave diathermy circuit in Fig. 1 was designed to meet all of the above requirements. It employs a single type UE468 oscillator tube operating on 27.12 mc with a power output of 300 watts. Use of one tube minimizes circuit complications and service factors by eliminating such matters as tube balance, excitation adjustments and balance, neutralization, and improper lineup of driver or power amplifier stages.

The Q of the tank circuit on full load is 90. The maximum frequency shift due to patient-circuit loading is ± 50 kc (Δf = tank efficiency multiplied by $f/4Q$). This holds for the condition of critical coupling, which just loads the circuit to rated full load with the patient circuit tuned to resonance.

The single-ended tank circuit permits use of a high tank capacitance, giving a high ratio of tank capacitance to tube electrode capacitance. This in turn tends to minimize frequency change with interchange of tubes having otherwise tolerable interelectrode capacitance variations.

The output of the generator is adjusted primarily by the variable coupling control. The maximum possible coupling is designed to the critical value corresponding to the highest patient-circuit resistance to be treated under normal conditions.

The parallel-tuned output circuit, controlled by the tuning capacitor, gives ample tuning range to resonate all types of applicators. Since the main switch is embodied in the coupling control, the operator automatically increases the coupling control from zero coupling each time the unit is turned on. The output of the unit is metered by measuring the difference between the plate and grid currents, to indicate true power independent of patient-circuit tuning for any given load condition.

Frequency shift due to thermal drift is controlled by a bimetallic temperature compensator. The thermal shift is held to 20 kc, with the greater portion of this shift occurring during the first two minutes of operation. The generator operates well within the FCC limits if the initial frequency is set correctly and the output control is not advanced to a position which grossly overcouples the patient circuit to the oscillator. Incorrect operation is only possible when the output circuit is not tuned to resonance.

Trimmer C_2 is used to adjust the frequency of the oscillator over a range of $\pm$ 200 kc from the center frequency. This range is adequate

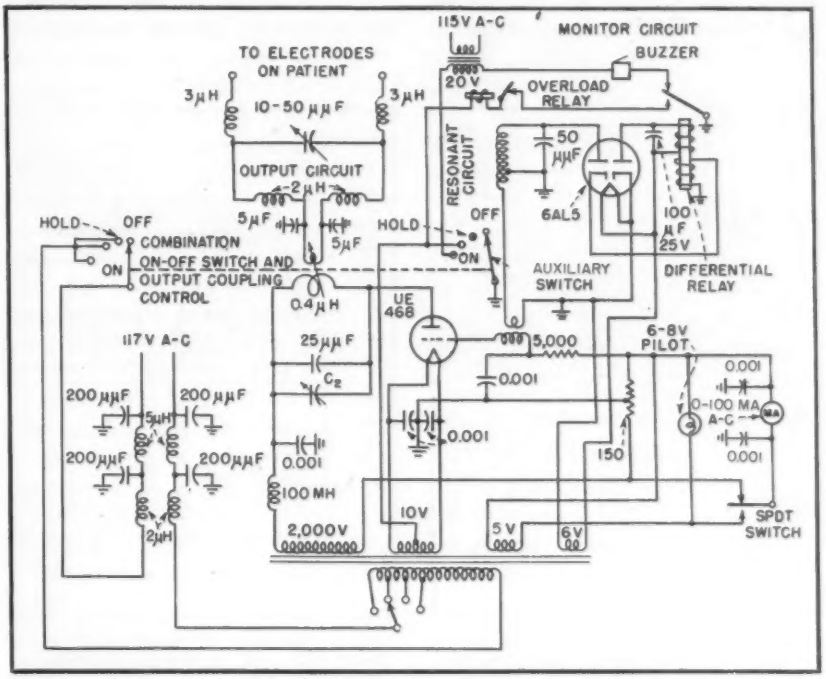

FIG. 1—Basic circuit of short-wave diathermy unit operating in 27.12-mc band and using monitor circuit to stop the oscillator and sound a buzzer when frequency drifts beyond legal limits

to compensate for frequency variations due to change of tubes or other components and mechanical instability.

Frequency Monitor

A monitor circuit insures that the unit will always operate within the band. It consists essentially of a thermally and mechanically stable high-Q resonant circuit which operates a sensitive relay through a rectifier tube. When the circuit is excited the relay completes the cathode circuit of the oscillator.

When the oscillator frequency deviates more than a predetermined amount from 27.12 mc, the voltage across the monitor circuit decreases to the point where the relay opens, interrupting the cathode circuit of the oscillator. At the same time a low-voltage buzzer is energized, notifying the operator immediately of the condition. The monitor circuit (covered in U. S. patent application) is set to allow operation in a band of ±100 kc; this is well within the FCC type approval limit of 70 percent of allocated channel width.

The uppermost curve in Fig. 2 illustrates the response of a simple resonant circuit energizing a relay through a rectifier to monitor a frequency band for various values of deviation from the frequency to which the circuit is tuned, expressed in effective resonant-circuit Q values. When the frequency deviates so that resonant-circuit response falls below the control level the relay will become deenergized. Such a method of control requires that the relay contacts be bridged by an auxiliary switch momentarily in order to start oscillations.

The lower solid curve in Fig. 2 shows that a 15-percent reduction in r-f excitation results in a 17-percent reduction in the pass band. This weakness of the simple system can be overcome by the use of a differential relay. One winding is connected to the resonant circuit, and the other winding is connected through a rectifier to a voltage proportional to the high-frequency exciting voltage of the resonant circuit, as in the monitor circuit of Fig. 1. These two windings are connected so their electromagnetic fluxes are adding in the magnetic circuit operating the relay armature.

The dotted curves in Fig. 2 illustrate the characteristics of such a differential circuit. A 15-percent reduction in excitation voltage here results in only a 7-percent change in frequency band width at the differential relay control level.

Operation of Circuit

When the main power switch in Fig. 1 is turned from OFF to HOLD, the oscillator tube and the rectifier in the monitor circuit warm up. Plate power is not, however, applied to the oscillator tube. During the brief period that the power switch is turned from the HOLD position to the ON position an auxiliary switch momentarily applies plate power to the oscillator tube. Oscillations start immediately, and if the frequency is within the operating band the monitor differential relay contacts close and hold the plate power on. If the oscillator frequency is outside the limits, the monitor relay will not hold the plate power on and a buzzer will operate.

Trimmer C_2 is adjusted by determining the low and high-frequency limits of the monitor and setting the trimmer at a point midway between these two limits. This is normally done after allowing the unit to warm up for two minutes, thus automatically compensating for the frequency shift due to initial heating.

Harmonic Radiation

The reduction of harmonic radiation of short-wave diathermy machines to limits prescribed by FCC allocations requires application of standard methods of shielding and filtering. In actual test it was found that a 40-millivolt 135-mc signal applied to the plate applicators would produce a field intensity equal to 25 microvolts per meter at 1,000 feet. This illustrates the degree of suppression required. Even though the actual signal voltage received by the field intensity meter decreases with the higher harmonics, the field intensity, as computed by the induced signal voltage and divided by effective length of the antenna, tends to stay high because the effective length of the antenna decreases directly with wavelength.

Harmonic tests are conducted preferably on open terrain. Field intensity meter readings are taken either 100 or 500 feet distant from the diathermy unit. The diathermy unit is mounted on a rotatable platform which is turned 360 degrees during a given reading. Maximum signals are recorded. The unit is connected to a gasoline-powered a-c generator and is tested with applicators under all conditions. Figure 3 shows typical results of tests performed on production units.

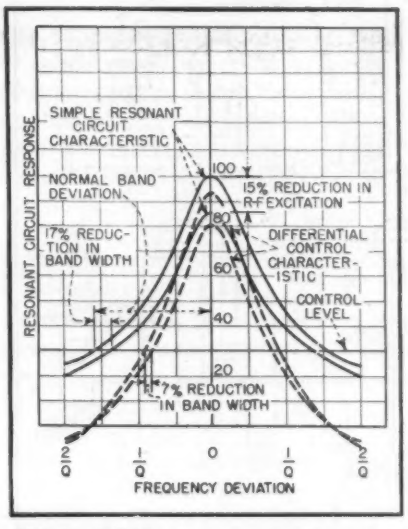

FIG. 2—Solid-line curves give characteristics of simple frequency monitor circuit, while dotted-line curves show how effect of reduction in r-f excitation of diathermy unit is minimized by using differential control in monitor circuit

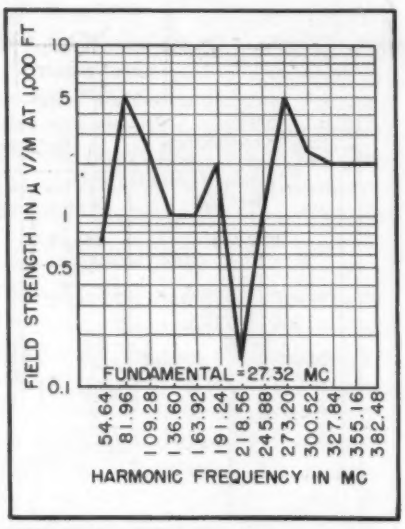

FIG. 3—Intensity of radiation of short-wave diathermy on various harmonics when center frequency is 27.32 mc. Unit represented here is well within legal maximum of 25 microvolts per meter at 1,000 feet

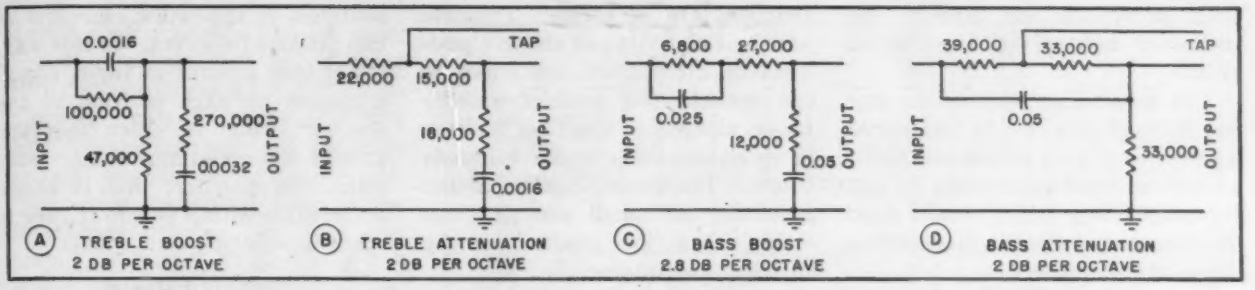

FIG. 1—Typical R-C networks used in tone control for boosting and attenuating audio signals. Taps on attenuation network provide half the indicated effect

Versatile Tone Control

Treble and bass frequencies are independently boosted or attenuated in steps to provide 121 different response curve combinations for reproduction of speech or music. Gain at 500-cycle crossover is automatically held constant by switching in cathode followers

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THE TONE CONTROL described here originated largely with a desire to compensate for the limitations of recording techniques. With it, treble frequencies can be boosted or suppressed, and bass frequencies can be similarly treated independently, all in small steps.

The bass and treble controls each provide sharp rise or fall starting at 500 cycles or any other crossover frequency chosen. Bass control produces no substantial effect above crossover, and treble control produces no substantial effect below. The rising or falling slope is adjustable in steps of one db per octave up to a maximum of 5 to 7 db per octave. The overall volume level at the crossover frequency is unchanged by applying any bass or treble compensation, or by applying both simultaneously. All frequency-determining components are resistances or capacitances. All curves flatten off above 10 kc and below 25 cycles.

R-C Networks

Selective frequency boost is achieved by attenuating one group of frequencies and readjusting the overall level with flat amplifiers. The basic R-C networks used for this purpose are shown in Fig. 1, along with the networks used primarily for attenuation.

Treble boost (Fig.1A) is obtained with a bass attenuation network having a gradual drop near the crossover and a sharp flattening off at the lower frequencies. When this curve is slid up the frequency axis until the sharp bend reaches the crossover frequency, it becomes treble boost.

Treble attenuation (Fig. 1B) gives an abrupt drop near the crossover frequency and a smooth flattening off at higher frequencies.

Bass boost (Fig. 1C) is obtained with a treble attenuation network having a gradual drop near the crossover and a sharp flattening off at the higher frequencies. When this curve is in effect slid along the frequency axis until the sharp bend occurs at the crossover frequency, it becomes bass boost.

Bass attenuation (Fig. 1D) gives an abrupt drop near the crossover frequency and a smooth flattening off at lower frequencies.

Any desired crossover frequency may be achieved by selection of resistance and capacitance values for the R-C networks. For example, doubling all indicated resistance values without changing the capacitances will shift the entire curve toward lower frequencies by a factor of two. Doubling all capacitances produces the same effect, while decreasing resistances or capacitances or both shifts the curve bodily toward higher frequencies.

The impedance any network presents may be altered by a factor N, without altering the frequency response curve, by multiplying all resistance values by N and at the same time dividing all capacitances by N.

Complete Circuit

The final tone control circuit is shown in Fig. 2, along with the response curve combinations obtainable and the control switch settings for each. Since all the required compensation cannot satisfactorily be provided in variable form in one network section, composite networks consisting of three such sections in tandem or cascade are used for bass and treble attenuation,

with provisions for tapping the composite network at the desired points.

The succeeding sections in any one network increase in impedance by a factor of four or five each time, so that succeeding sections do not furnish loading which would alter the frequency response characteristics of preceding sections.

Because of the nature of the basic bass boost section, the building up of a network from several such sections would add many bulky components. Instead, therefore, a switching arrangement was developed wherein three sections of 1.4, 2.8, and 2.8-db boost per octave were combined successively to give in turn 1.4, 2.8, 4.2, 5.6, and 7-db boost per octave. The same system is employed for treble boost, and the network sections again increase in impedance as they are added.

Two six-pole eleven-position switches are required. The five positions of boost and the five positions of attenuation are wired to one switch for each frequency range, along with a neutral position in which no bass or treble alteration occurs. Continuous control is not provided, but small enough steps make the action gradual as the switches are rotated.

The overall result, then, is to have one switch for bass, giving from 7 db of boost per octave to 5 db of suppression per octave in ten steps, and one switch for treble, giving from 5-db boost per octave to 6-db reduction per octave in ten steps, with no interaction between controls. The words per octave here refer to the number of octaves displacement from 500 cycles.

In order to achieve a constant volume level at the crossover frequency, a stepping gain control was added, ganged to the bass and treble switches, in the cathode circuits of two cathode followers. In this way, the proper amount of input signal is chosen for each position of the selector switch in order that the gain at 500 cycles may remain constant. In practice, this is easily achieveable within one db if care is taken in selecting components.

Cathode Followers

The cathode followers serve the main purpose of transforming a high-impedance input signal down to a low impedance so that the networks may begin at low impedance and build up as described. It has been found that stray coupling between high-impedance networks can seriously alter the ideal frequency response curves. With capacitance values all larger than 400 micromicrofarads, a small unintended coupling capacitance (on a switch wafer, for example) will not pro-

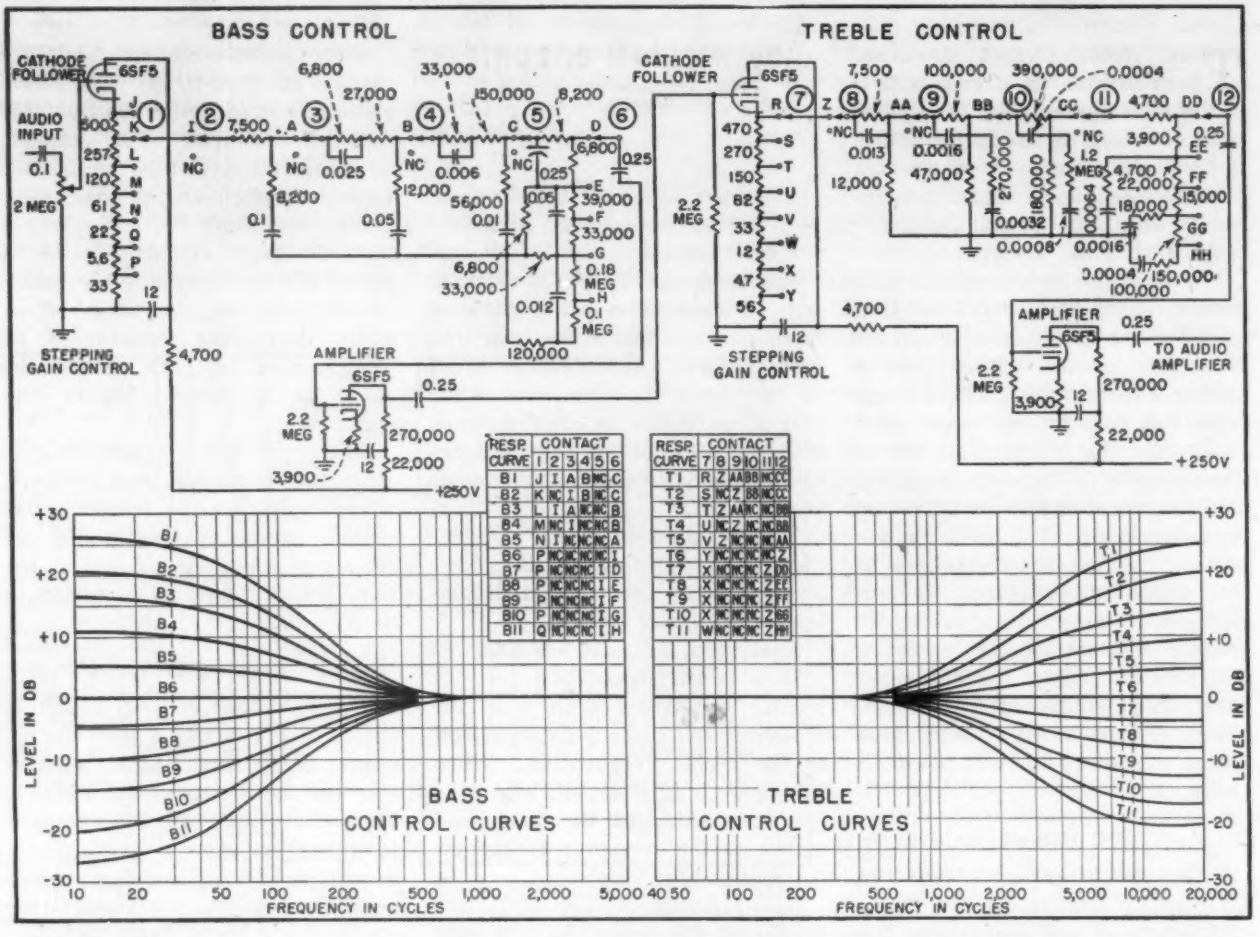


FIG. 2—Complete tone control system. When inserted in an audio amplifier, its overall gain is zero at the 500-cycle crossover frequency. The inset tables give the positions of the contact arms of the two six-pole eleven-position control switches to provide the indicated bass and treble control curves. Treble curves were taken with bass control at B6 (neutral), and bass curves with treble control at T6

duce a noticeable effect on the tone.

Amplification must be provided (not necessarily within the tone control) in order to re-establish the original volume level. At the same time, it is advisable to amplify and then again transform down to low impedance between the bass and treble controls. This serves the added purposes of isolating the bass and treble components electrically and keeping either from operating at too low a voltage level. All these networks are bound to have insertion loss at any frequency, and a total of 40 db of attenuation at 60 or 120 cycles (as provided by bass suppression and treble boost, before re-establishment of the 500-cycle level) could push the signal into the heater-to-cathode hum voltage level.

Amplifier Design

Choice of tubes for this tone control proved somewhat vexing. The 6SL7 twin high-mu triode would have been most convenient, but even a 6SL7W proved to be usually too microphonic, and always too rich in hum introduced through the heater circuit. The 6SN7 does not have enough gain; the 6SC7 has only one external cathode lead. The 6SF5 high-mu triode was found to be available and free from hum in a sufficient number, and so this type was decided upon.

In the amplifier stages, cathode resistors were left unbypassed to make the neutral amplification curve as flat as possible, at the sacrifice of some gain. A total of 12 db more of gain may be obtained by suitable bypassing of these two resistors. All plate supply circuits must be decoupled as shown, and all blocking capacitors must be large enough so that low frequencies are not attenuated.

The input signal level must be low enough so that, after boosting, neither the bass nor the treble signal will overload either level-restoring amplifier. A gain control is therefore provided directly at the input to the tone control. This is not intended as a main gain control for the entire control and program amplifier combination, but as an auxiliary which may be set according to the maximum level of the incoming signal.

In commercial recording, compression takes place before the mechanical limitations of recording techniques produce their tone-modifying effects. Therefore, the tone control should be used before a volume expander. This also lessens the danger of overloading the amplifiers in the tone control.

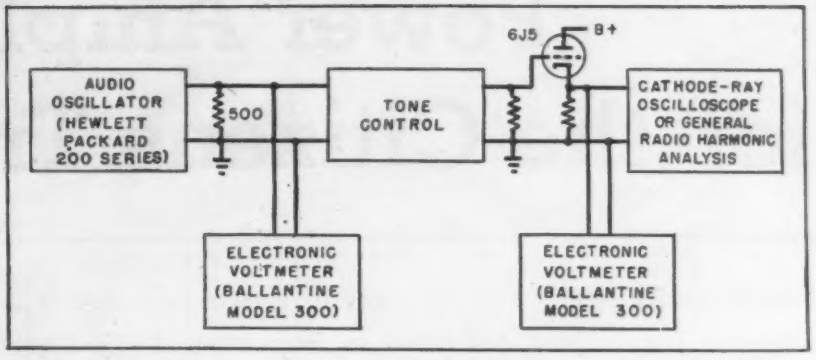


FIG. 3—Method used for testing individual R-C networks and complete tone control system

Construction and Testing

All parts were selected, using a resistance bridge and a capacitance bridge, from stock ½-watt resistors in RMA sizes and stock capacitors. In many cases resistance values were changed slightly from nominal values shown in order to achieve a smooth consistent family of curves.

Assembly may be along lines conventional for low-level audio circuits. Compactness was achieved by wiring virtually all the resistors and capacitors on the two switches before installing the switches on the chassis. The tone control with its two switches, four tubes, a spare selected 6SF5 tube and a 3-tube a-m tuner were assembled on a 9x11-inch chassis, the audio amplifier and power supply being remote.

Checking Response Curves

A testing method was evolved for this type of work, which eliminated disturbing effects due to such factors as voltmeter frequency response, loading, signal generator variations, and distortion. As shown in Fig. 3, an audio oscillator with load resistor was fed to the input of the tone control, across which an electronic voltmeter was placed. The linear db scale on the Ballantine voltmeters simplified measurements since all data could be obtained directly in decibels and plotted immediately; any odd points could be immediately investigated.

Each network was tested individually, after which the entire tone control was tested as a unit.

The output from the last 6SF5 was transformed down to low impedance in an auxiliary cathode follower (6J5) and another voltmeter was placed across the cathode follower cathode resistor. The oscillator was set for 500 cycles, its output set for midscale (10 db) on the input monitor meter, and the input gain control adjusted for midscale (10 db) on the output meter, on the 1 volt scale.

Precautions

Any change in oscillator output as frequency was changed was eliminated by always adjusting the oscillator output control so that the input meter read 10 db. A series of measurements was taken by setting the frequency, setting the oscillator output, and recording the output reading in db as the treble or bass control was varied throughout its range. The tone control net effect is the output reading in db minus 10.

Great care must be taken in planning this type of measurement since it is easy to overlook a cable lumped capacitance, which will change beyond recognition an otherwise desirable curve. It is also advisable to monitor, on a good oscilloscope or harmonic analyzer, the audio output from the tone control, to avoid recording false readings due to overloading and consequent waveform distortion.

The author wishes to express appreciation to Dr. Hugh F. Gingerich, to whom credit for the basic network design is due.

Power Amplifier for the Citizens Transmitter

Construction details and circuitry of a two-stage power amplifier for use in conjunction with the transmitter described in November 1947 ELECTRONICS. Simplified design of cavity resonators and mounts permits duplication of the unit with the use of hand tools only. No machining is necessary

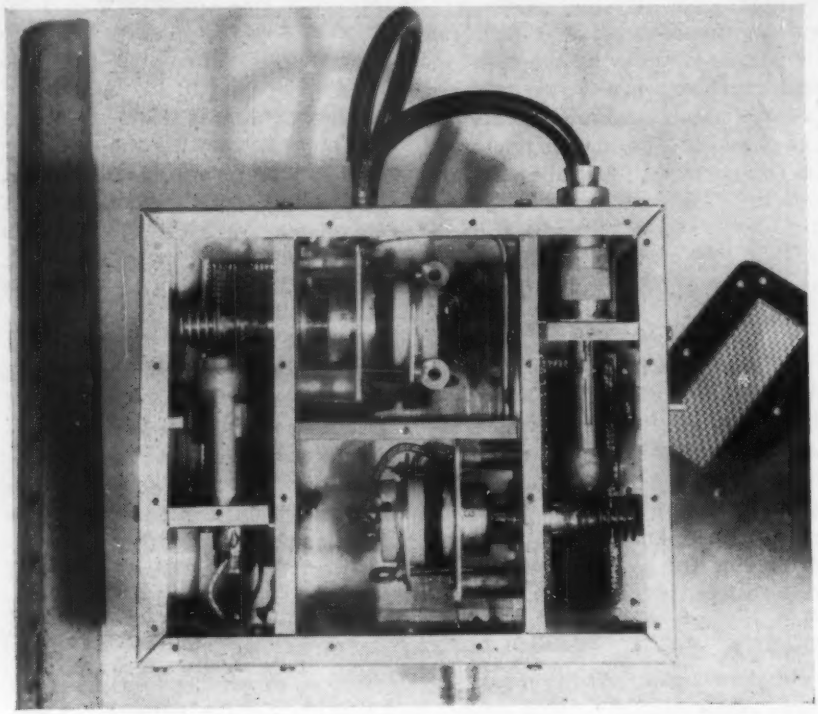
By WALTER C. HOLLIS
Project Engineer
Engineering Division
The W. L. Maxson Corporation
New York, N. Y.

Part V

THE UNIT illustrated is designed to be added to the ELECTRONICS Citizens transmitter to provide the higher power needed for covering greater distance and more reliable communication. With it, the quarter-watt output of the mobile transmitter is increased to 10 watts, a total gain of 16 db. Although intended primarily for fixed station operation, where a conventional 115-volt power line is available, the input requirements are sufficiently low as to permit mobile operation from a vibrator or dynamotor power supply.

The power amplifier consists of two stages of class-C grounded-grid amplification employing type 2C43 tubes. The complete circuit diagram is shown in Fig. 1.

The first stage is operated single ended and is driven through a type-N panel jack, J_1. Loop L_1 is a short length of tubing which approximately resonates out the grid-to-cathode capacitance of V_1. A wire shielded within the tubing provides one connection for the heater voltage and the other is returned to ground through an internal connection in V_1. Capacitors C_1 and C_2 are button mica types that maintain both filament connections and the three cathode d-c connections at the same r-f potential. The cathode r-f connection is provided through a built-in capacitor between the shell and cathode of the 2C43. Cathode resistor R_1 develops the required grid bias and serves as overload protection for the tube in case of drive failure.

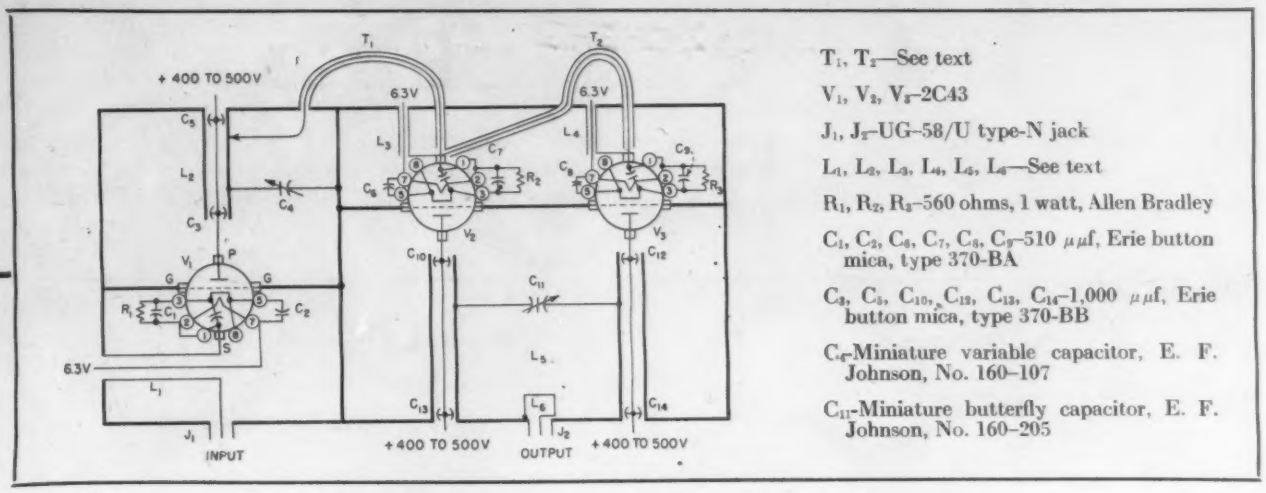


Complete amplifier with one cover removed. Resonant cavities are formed by the metal case and the partitions

Coupling

The output tank circuit is of the transmission-line type and consists of a length of short-circuited transmission line, L_2, resonating with the grid-to-plate capacitance of V_1, and a variable capacitor, C_4, located part way up the line. The resonant circuit thus formed is shunt fed through a pi filter consisting of C_3, C_5 and the inductance of the length of wire connecting these capacitors. Output from the first stage is fed to the second stage by means of an adjustable tap on L_2 through a length of transmission line, T_1.

The second stage consists of two 2C43 tubes, V_2 and V_3, operated in push-pull. Tubing L_3 and L_4 are similar to and serve the same purpose as L_1. Capacitors C_6, C_7, C_8 and C_9 have the same function as C_1 and



T_1, T_2—See text

V_1, V_2, V_3–2C43

J_1, J_2–UG–58/U type-N jack

L_1, L_2, L_3, L_4, L_5, L_6—See text

R_1, R_2, R_3–560 ohms, 1 watt, Allen Bradley

C_1, C_2, C_6, C_7, C_8, C_9–510 $\mu\mu$f, Erie button mica, type 370-BA

C_3, C_5, C_{10}, C_{12}, C_{13}, C_{14}–1,000 $\mu\mu$f, Erie button mica, type 370-BB

C_4-Miniature variable capacitor, E. F. Johnson, No. 160–107

C_{11}-Miniature butterfly capacitor, E. F. Johnson, No. 160–205

FIG. 1—Complete circuit of the two stages of the power amplifier

C_2. Resistors R_2 and R_3 provide grid bias and overload protection. The cathodes of V_2 and V_3 are driven by the output of V_1 through transmission line T_1. Amplifier V_2 is driven directly and V_3 is driven through an additional half-wave line, T_2, which serves as a phase inverter. This is one form of the balance-to-unbalance transformer (balun).

The output tank circuit consists of a length of short-circuited parallel transmission line, L_5, resonated by the grid-to-plate capacitance of V_2 and V_3 and a butterfly capacitor located part way up the line. The resonant circuit thus formed is shunt fed through pi filters consisting of C_{10}, C_{12}, C_{13}, C_{14} and their respective connecting leads. The output of this stage is coupled out through J_2 by means of coupling loop L_6.

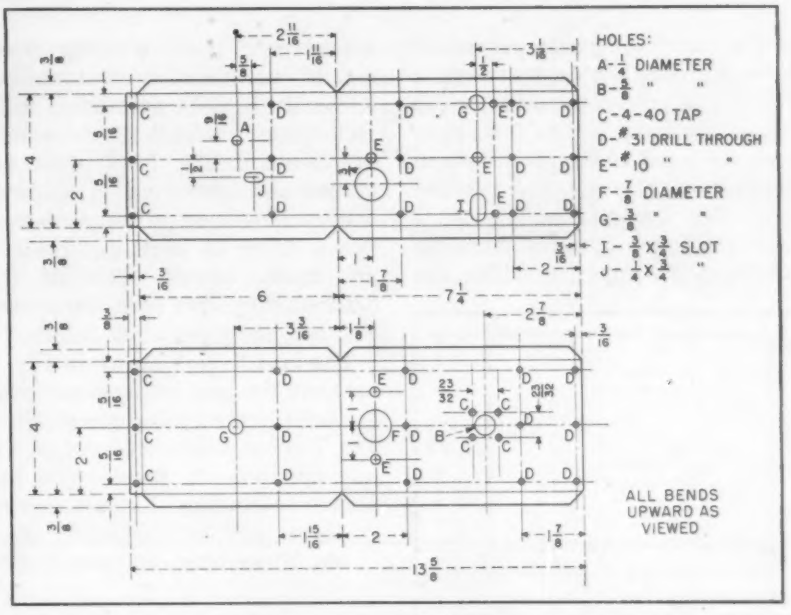


FIG. 2—Layout of two L-shaped shields that form the metal cabinet. All dimensions are given in inches

Construction Details

As shown in the accompanying photographs, the two stages of amplification are assembled within a sheet-metal shield box 7 1/16 x 6 1/16 x 4 1/16 inches, consisting of two L-shaped flanged parts and two covers.

The shield box is divided into four compartments by three partitions. One compartment each is used for the input cathode circuit of V_1, output resonant circuit of V_1, input cathode circuits of V_2 and V_3, and output resonant circuit of V_2 and V_3. All parts for the shield box are made of 1/32-inch sheet brass and held together by 4-40 binding-head screws.

The layouts for the two L-shaped flanged parts are shown in detail

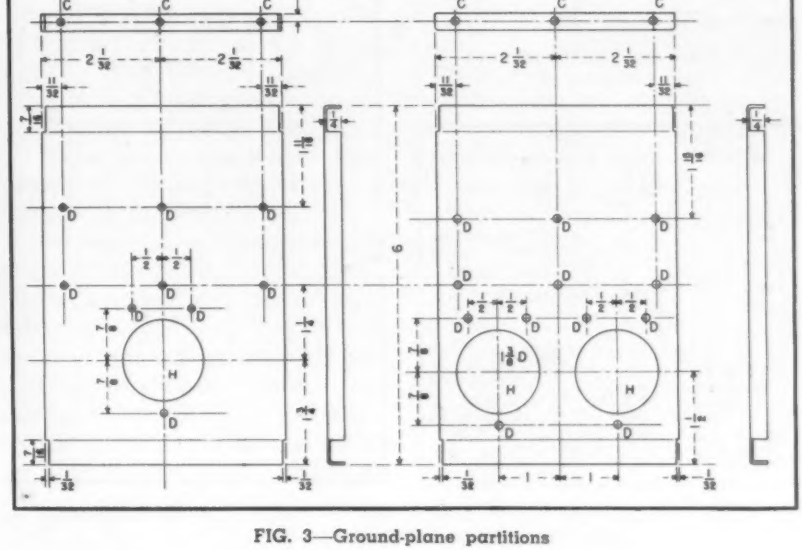
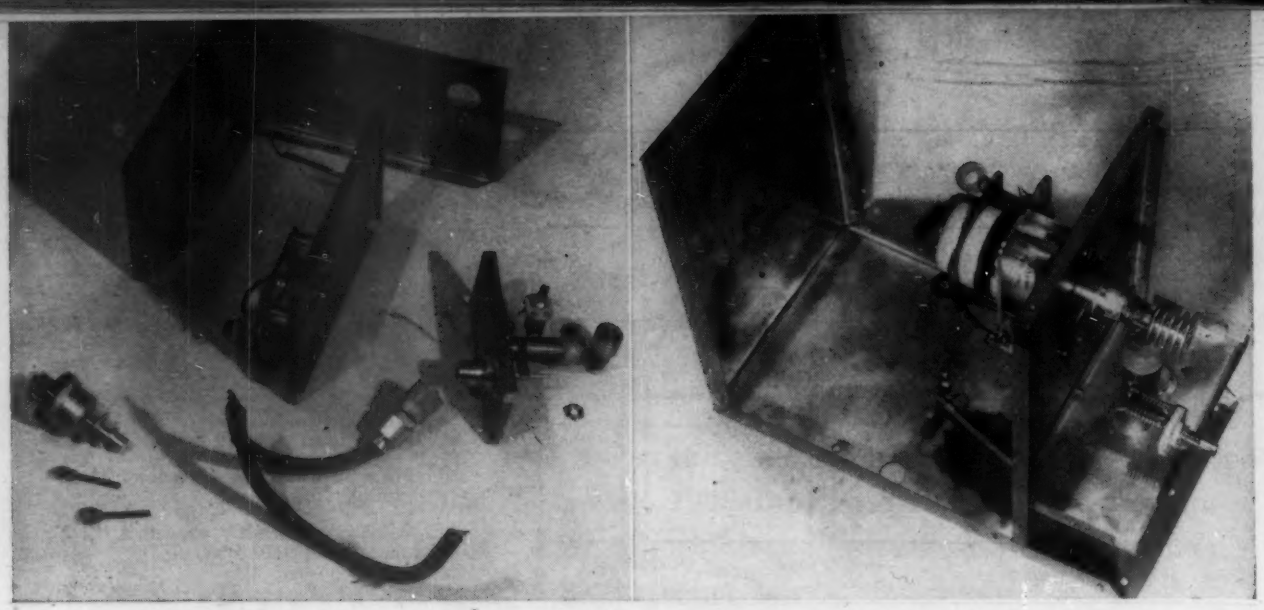


FIG. 3—Ground-plane partitions



Single-ended input stage at right uses components at left and mounts with output stage to form the metal cabinet

in Fig. 2. Two partitions, which serve as ground planes, are shown in Fig. 3. The smaller partition, which shields the input of the first stage from the input of the second stage, is shown in Fig. 4. The two line assemblies are detailed in Fig. 5 and 6. Figure 5 shows assembly details of the input amplifier line assembly. Figure 6 omits these details as they were identical. Assembly is done exclusively with soft solder. Details of the covers are shown in Fig. 7. Two are required and screening is soldered over each opening on the inside surface. After all parts for the box are made, tapped holes on the flanges are spotted from the covers. Figure 8 shows all other details.

The grid fingers shown in Fig. 8 are centered and soft soldered over the holes in the ground planes (Fig. 3). They should be soldered on the side opposite the flange with the fingers protruding. Fingers similar to these may be purchased from James Millen Mfg. Co. as part No. 33446. Only the middle size is used. After all metal parts are made, they may be silver plated for improved conductivity, as was done with the model.

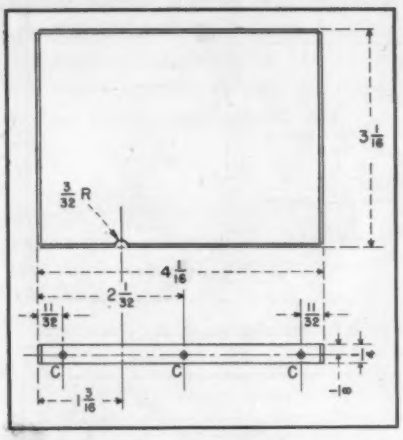


FIG. 4—Small partition to separate the stages

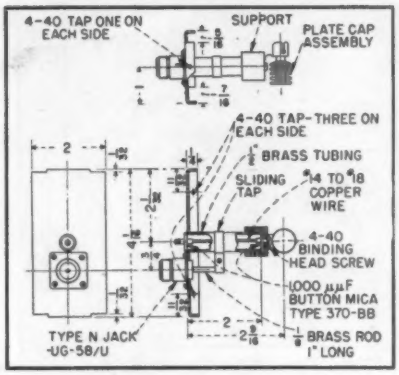


FIG. 5—Resonant-line assembly of input amplifier

Assembly

All metal parts are held together by 4-40 screws and lock-washers. In addition to the parts called for in Figures 1 to 8, the following are required: four feed-through terminals, such as Vitroseal Corp. Terminal No. 1901-9LHT; about 18 inches of shielded wire, such as Precision Tubing's No. 20(10/30) wire in silver-plated copper shields, 0.1495 O.D. x 0.011 wall thickness; three Millen type 33008 steatite

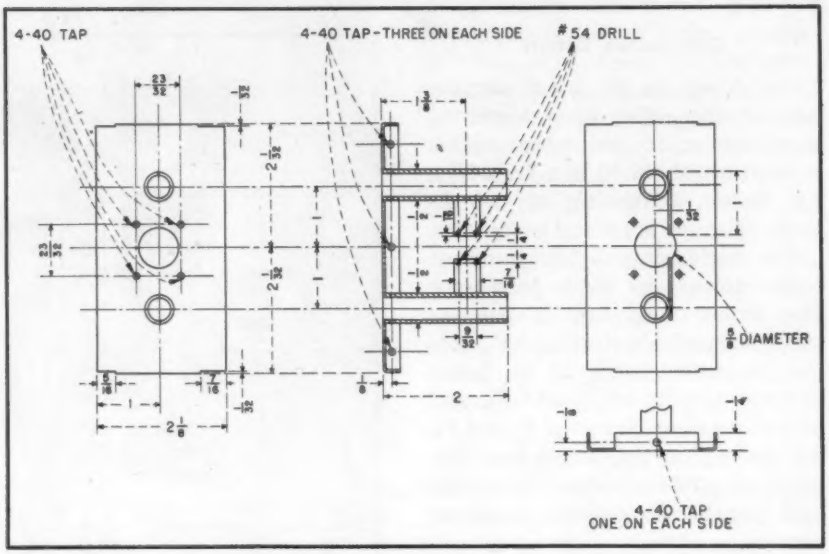
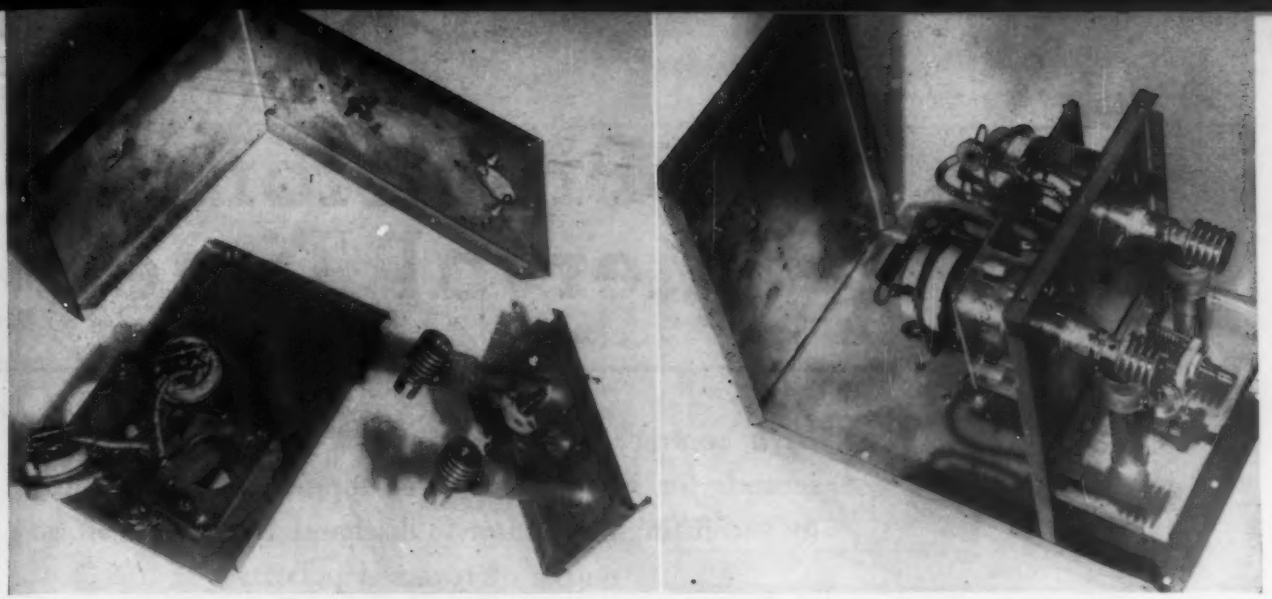


FIG. 6—Output amplifier resonant-line assembly as shown pictorially at top of following page



Components and shields of the push-pull output stage, left, form the assembled unit at right, half of the cabinet

octal sockets; six 6-32 fillister head screws, 1¼ inches long; about 18 inches RG-5/U cable; and one UG-18/U plug.

The shielded wire is soldered to the chassis and cathode mount as shown in the photographs to form L_1, L_2, and L_4, respectively. The inner wire supplies the filaments of V_1, V_2, and V_3. Filament and cathode connections are made through an octal socket.

The cathode bypass capacitors and bias resistor are mounted on the socket as shown in the photographs. The outer rim of each button mica capacitor is soldered to terminals 3, 5, and 8 of the socket and one is stacked above the other. The lug of the lower capacitor is soldered to terminal 2, which is connected to terminal 1, providing a ground return to the shell of the 2C43. The lug of the upper capacitor solders to terminal 7 which connects to the filament lead. The bias resistors span terminals 1 and 5.

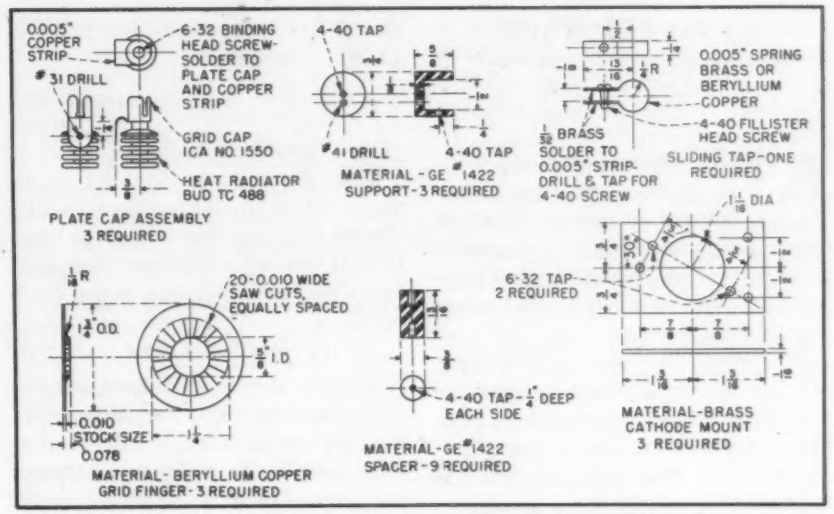

0.005" COPPER STRIP
#31 DRILL
6-32 BINDING HEAD SCREW-SOLDER TO PLATE CAP AND COPPER STRIP
GRID CAP ICA NO. 1550
HEAT RADIATOR BUD TC 488
PLATE CAP ASSEMBLY 3 REQUIRED
4-40 TAP
#41 DRILL
4-40 TAP
MATERIAL - GE #1422 SUPPORT - 3 REQUIRED
0.005" SPRING BRASS OR BERYLLIUM COPPER
4-40 FILLISTER HEAD SCREW
SLIDING TAP - ONE REQUIRED
BRASS SOLDER TO 0.005" STRIP-DRILL & TAP FOR 4-40 SCREW
20-0.010 WIDE SAW CUTS, EQUALLY SPACED
O.D.
I.D
0.010 STOCK SIZE
0.078
MATERIAL - BERYLLIUM COPPER GRID FINGER - 3 REQUIRED
4-40 TAP - DEEP EACH SIDE
MATERIAL - GE #1422 SPACER - 9 REQUIRED
6-32 TAP 2 REQUIRED
DIA
MATERIAL - BRASS CATHODE MOUNT 3 REQUIRED

FIG. 8—Small parts required are plate caps, grid fingers, supports, spacers, tuning clips and cathode mounts

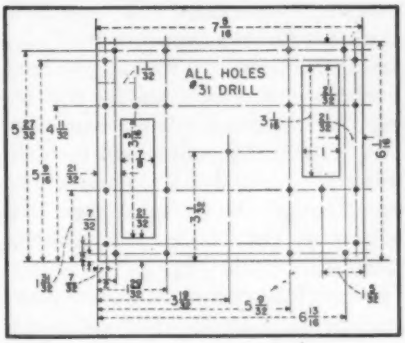


FIG. 7—Copper screening is soldered over the openings of the covers

The resonant lines are assembled as shown in Fig. 5. The GE 1422 supports are secured to the brass tubing by means of 4-40 set screws. The purpose of the support is to take all stress off the fragile button mica capacitors. The rest of the assembly is readily completed by referring to the photographs.

The balun, T_2, is an 8¾-inch length of RG-5/U cable with the inner conductors soldered to the cathode mounts of V_2 and V_3. One side of the outer shield is connected to the shield of transmission line T_1. The inner conductor of T_1 also terminates on the cathode mount of V_3. Line T_1 is a 6-inch length of RG-5/U cable terminated in a UG-18/U plug.

The first stage showed a power gain of 10 db with a driving power of ¼ watt, and an output of 2.5 watts. The plate input was 22 ma at 500 volts. The second stage showed a gain of 6 db with an output of 10 watts. The input was 30 watts, yielding a plate efficiency of 33 percent. If lower power is desired, the first stage may be used alone.

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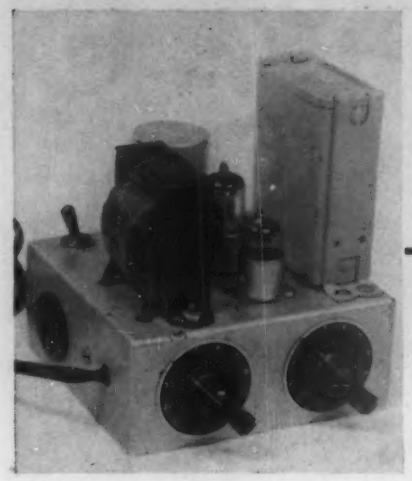
William B. Lurie, Citizens Band Transceivers, ELECTRONICS, p 76, Aug. 1948.

Precision Interval Timer



Complete timer chassis. The relay is mounted underneath

High accuracy of timing intervals from 0.01 to 100 seconds for industrial control applications is provided by permitting a capacitor to discharge through a voltage source of reversed polarity

By SIDNEY WALD

Aviation Equipment Engineering
RCA Victor Division
Camden, New Jersey

A WIDE variety of modern industrial jobs require accurate timing. Control of current duration in welding and timing of exposure in high-frequency heating and photographic enlargement are but a few possible applications.

Electronically operated timing circuits almost universally employ a combination of resistance and capacitance, wherein the measured interval is the time required for the capacitor to reach some predetermined voltage. While the relationship between the charge or discharge time and RC product is predictable and accurate the practical embodiment of this statement usually results in the introduction of other circuit variables such as tube electrode potentials, aging and loss of calibration through tube replacement.

The electronic timer to be described eliminates these sources of error while retaining simplicity.

The formula which governs the discharge of a capacitance through a resistance is

$$v = V_0 \epsilon^{-t/RC} \qquad (1)$$

where v = voltage across the capacitor after time t seconds
V_0 = initial voltage across the capacitor
C = capacitance in μf
R = resistance in megohms
$\epsilon = 2.718$

If we permit the capacitor to discharge to the point where $v = (1/n)\,V_0$ we have

$$\frac{1}{n}(V_0) = V_0 \epsilon^{-t/RC}$$

$$\text{or } \epsilon^{-t/RC} = 1/n$$

Thus for a given R and C it always takes the same time to discharge the capacitor to a given fraction of the initial voltage. Note that this time is independent of the value of V_0.

Modified Circuit

By the simple expedient of discharging the capacitor through a voltage source of reversed polarity, it is possible to make $v = 0$ when the ratio $1/n = 1/2$. This type of discharge is shown in Fig. 1. Making use of these facts in Eq. 1 results in the following

$$\epsilon^{-t/RC} = 1/2 \qquad (2)$$

$$\log_\epsilon 1/2 = -t/RC$$

$$\text{from which } t = 0.693\,RC \qquad (3)$$

Thus, after 0.693 RC second, the voltage across the capacitor will be zero regardless of the initial voltage V_0.

In the circuit of Fig. 2, a miniature thyratron fires when its grid voltage passes through zero. A relay in the plate circuit pulls in and either energizes or interrupts a load circuit, depending on the contact arrangement. To repeat the cycle, the thyratron plate current is momentarily interrupted. This action permits the negative grid to regain control, holding off conduction until the capacitor discharge curve again passes through zero.

When the device is first connected to the a-c line, the 4-μf timing capacitor, C_t, is in a discharged state and consequently the thyratron fires as soon as the plate voltage derived from the 6AL5 power supply builds up. This action causes the plate circuit relay to pull in and C_t charges to 200 volts negative, with respect to the cathode of the 2D21. The grid of the latter, being permanently connected to C_t, likewise goes 200 volts negative. The thyratron remains in a conducting state, since one property of gas-filled tubes is the loss of control by the grid once the gas ionizes.

The circuit is now ready for the initiation of a timing cycle. It is accomplished by momentarily interrupting the continuity of the plate circuit. When the toggle switch marked RECYCLE is thrown to either position, the plate circuit is interrupted for a period equal to the transit time of the switch element. For the ordinary toggle switch, this may amount to a few milliseconds.

The tube is thus extinguished, the relay is de-energized and the highly negative grid regains control. At the same time, the normally closed contacts on the relay change the circuit so that the timing capacitor starts to discharge through the decade resistor (marked $\times$ 1 and $\times$ 10) and through the power supply. The action of the discharge circuit is clearly shown in Fig. 1.

When the potential across the capacitor reaches about 2 volts, the thyratron fires and the relay pulls in and remains that way until the

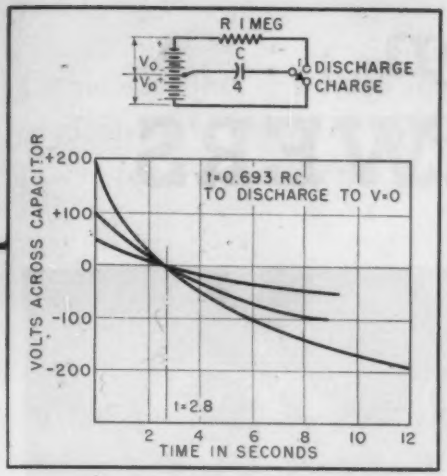


FIG. 1—Discharge of *RC* circuit

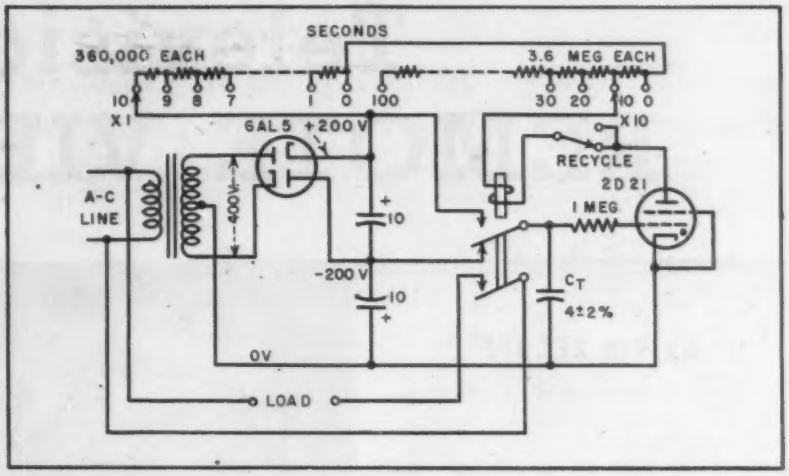


FIG. 2—Stable timer circuit provides intervals repetitive to 0.75-percent accuracy

circuit is again recycled. If a load, such as photographic enlarging lamp is connected in series with the a-c line and another pair of normally closed contacts on the relay, the light will go on for the precise period of time determined by the setting of the resistor decade switches.

Accuracy

The accuracy of the timing interval which may be obtained with this circuit depends on two principal factors, slope of the discharge curve near the firing potential of the thyratron and tolerance of the timing resistors and capacitor. Both of these are not only controllable but highly stable.

The value of the slope of the discharge curve at the firing point can be shown to be V_o/RC volts per second where V_o is initial voltage across the capacitor, R is given in megohms and C in microfarads.

To ascertain the timing error due to variation in firing potential of the tube, assume a maximum grid voltage drift of plus or minus 1 volt.

For a timing interval of 1 second, $RC = 1/0.693$ or 1.44; $V_o/RC = 200/1.44 = 139$ volts per second.

A more useful concept is the number of seconds per volt. Thus, $1/139 = 0.0072$ second per volt. For the assumed variation in firing potential, we have a timing error of ± 0.0072 second. Since we were considering an interval of one second, this is equivalent to an error of ± 0.72 percent.

For a timing interval of 100 seconds, we have an inverse rate of 0.72 second per volt and again the error is $\frac{0.72 \times 100}{100} = \pm 0.72$ percent.

This shows that regardless of the timing interval, the percent error due to small variations in critical grid potential is fixed and, for most purposes, insignificant.

Resistance and capacitance tolerances affect the accuracy of timing directly since the measured interval is directly proportional to RC. If we consider equal tolerances on the capacitance and resistance, then the timed interval $t = k\ R\ (1 \pm p)\ C\ (1 \pm p)$ where p = percent tolerance and $k = 0.693$. This leads to the relationship, $t = k[RC \pm RC\ (2p) + RCp^2]$.

For tolerances up to 10 percent, the second order term may be disregarded with the result that the resulting interval is in error by double the percent tolerance on either R or C. Thus, to insure one-percent accuracy, one must use half-percent resistors and capacitor.

An interesting case of cancellation occurs when the tolerance of one component is on the high side and that of the other component is equally on the low side. Then $t = k\ RC\ (1 - p^2) = k[RC - RCp^2]$.

For example, if the resistance is 10 percent high and the capacitance 10 percent low, the product error is 1 percent low. For 20-percent components, the timing error would be on the low side by only 4 percent.

The present design will give electronically timed intervals which are repetitive to an accuracy of at least 0.75 percent and absolute within about 5 percent, from 1 second to 110 seconds in 1-second increments. By making use of the relationship, $t = 0.693\ RC$ and using suitable values of R and C, it is possible to extend the timing range considerably below and somewhat above that given. The plate circuit relay operate time limits the shortest possible timing operation. With ordinary relays, it is possible to go down to 0.01 second. There are two limiting conditions for measuring long intervals. One is the necessity for extremely large RC values and the other the need for a steep discharge curve at the firing point.

Maximum Time Interval

With 400 volts on the plate of the 2D21, a 10-μf timing capacitor and a discharge resistance of 43.3 megohms, a maximum of 5 minutes might be successfully attained. It is believed, however, that a mechanical timer of some type would be inherently more suitable for such comparatively long intervals. The difficulties involved in procuring and maintaining extremely high stable RC are well known and in spite of recent advances in insulation and hermetic sealing techniques, it is well to avoid such circuitry wherever possible.

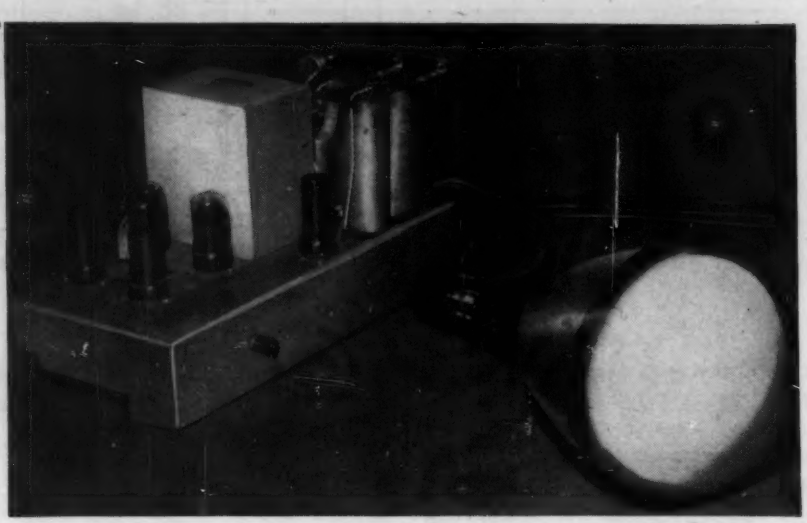
Credit is due J. S. Russo, also of Aviation Equipment Engineering, who was instrumental in the development of this electronic timer.

Television REMOTE VIEWERS

By VIN ZELUFF
Associate Editor
ELECTRONICS

THE ADVENT of television has brought unusual desires to many set owners like the author. One of these, the desire for a larger screen, has not been found too important after the first year of operation. More confining have been the limitations imposed by having only one picture tube in the home. This tends to involve constant attendance in the living room when duty, homework, mealtime and other activities require presence in other rooms away from the picture tube.

In answer to this second desire, three different remote viewers have been devised to provide video programs in other rooms. These viewers permit occasional monitoring of the evening programs while engaged in other tasks and also permit a large number of people to be entertained in several groups of convenient size. Having two or more screens for larger groups eliminates the confusion of assembling all available chairs in one room.



Independent viewer for attachment to video amplifier of any receiver. A second chassis, not shown, contains the low-voltage power supply, audio amplifier and loudspeaker

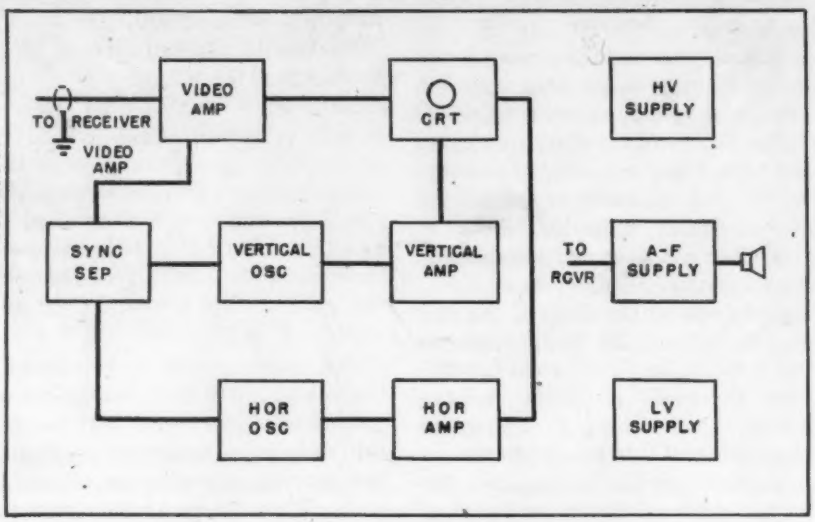


FIG. 1—Independent remote viewer contains its own sync-separation and deflection oscillators and is fed from the cathode of the video amplifier stage of any receiver

Independent Seven-Inch Viewer

The television receiver itself contains a seven-inch tube requiring electrostatic focus and deflection. For the first remote viewer, similar video and deflection circuits were assembled to form the unit shown in the block diagram of Fig. 1. This unit is an independent viewer that requires only a video signal of about two volts for picture operation. It contains cathode-coupled multivibrators for both vertical and horizontal oscillators, deflection amplifiers, a sync separator and, in the interests of economy, a single-stage video amplifier. For the same reason, d-c restoration is accomplished by utilizing the current through the grid resistor of the video amplifier tube.

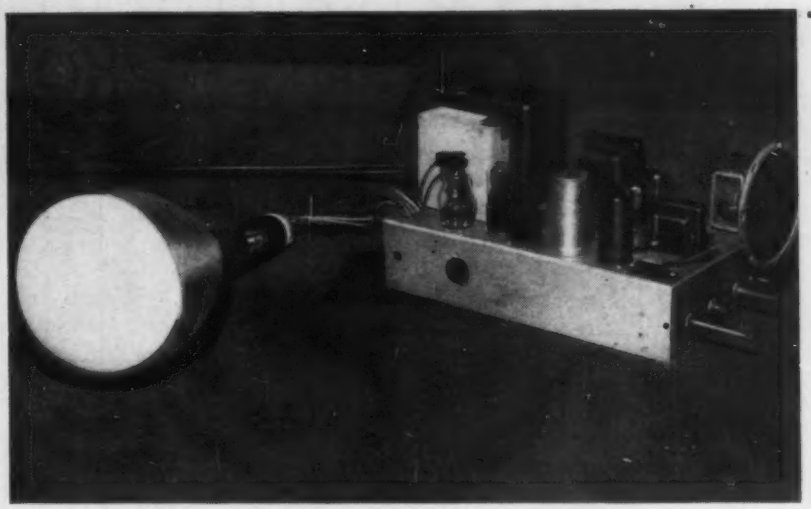
An unterminated coaxial cable is used to carry the video signal to the remote viewers. A cathode follower was installed at the receiver for feeding the video signal at low output impedance to the cable.

It was considered desirable to investigate the possible design of simpler remote viewers. Here simplification of circuit connections and minimizing of changes in the receiver were indicated.

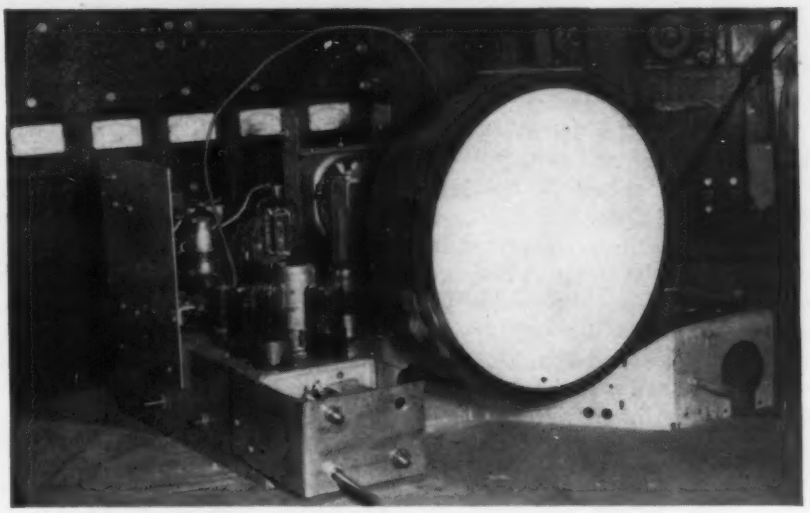
Design Simplification

Elimination of the extra tube for the cathode follower was desirable and found feasible. This was accomplished by inserting a 500-ohm resistor in the cathode circuit of the receiver's video amplifier and feeding the voltage developed

Cathode loading of a video amplifier stage in a receiver permits feeding two different types of picture-tube repeaters. By the same method, a third type, a simple slave repeater, can be fed from one of the viewers or from a receiver having electrostatic deflection



Complete slave viewer and audio channel. The electrostatic independent viewer or the receiver is used as a master unit



Ten-inch independent viewer constructed on a prepunched chassis. Only the video cable and audio line are needed for operation of this unit

across it to the remote viewers. The normal plate load circuit of the video amplifier was left unchanged. The final circuit is shown in Fig. 2. Only slight loss of video voltage to the receiver picture tube resulted from the dual output loading, and this was readily compensated by adjustment of the i-f gain control used as a contrast control.

The video signal has been fed through various types of cable, including RG8U, RG59U, microphone cable and even 300-ohm flat transmission line. All of the shielded types proved satisfactory in lengths up to 100 feet. Distances greater than this would not usually be encountered in the average home and would probably require a terminated line to eliminate standing waves at the highest frequency.

The independent viewer can be connected to any receiver at a point where a positive video signal of the proper voltage is available. If it is necessary to use a negative signal, the input can be made to the cathode of the remote's video stage.

The circuits of several receiver models available show an unbypassed cathode resistor in one of the video amplifier stages. From this point, these sets can be connected to remotes with only a possible addition of a signal divider if the video level is too high.

The first remote viewer included its own sound channel, using the simple intercarrier system, for demodulating the f-m signal produced at 4.5 megacycles by the transmitter. This required four tubes and was found to be an unnecessary luxury. A single audio stage is used in the viewers illustrated. Each of these is fed by an audio line from the receiver.

An alternative would be to eliminate the audio tube and connect loudspeaker voice coils to the audio line with low-impedance pads for individual control of audio level at each viewer. The system shown was adopted because of simplicity in circuit arrangement, as well as because it allows any remote viewer to be operated at a higher sound level than the receiver.

The picture controls of the independent viewer are essentially the same as those in a conventional receiver. Width, height, brightness, focus, vertical and horizontal frequency and centering controls are provided. Sufficient variation of contrast is provided by a 100-ohm rheostat in the cathode circuit of the video amplifier.

Simplified Seven-Inch Viewer

Cathode loading suggested a means of designing a slave remote unit in which there would be no

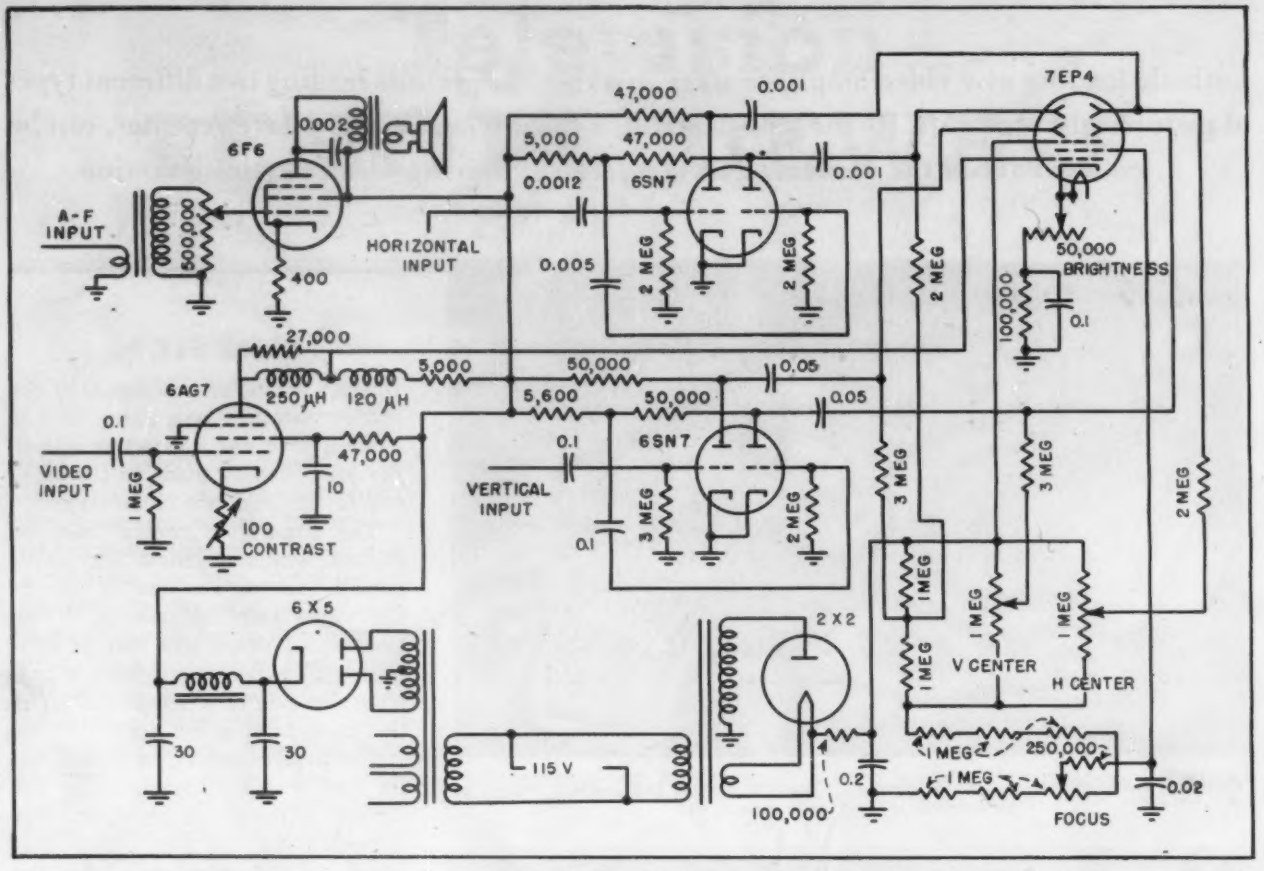


FIG. 3—Complete circuit of slave viewer. Three 35-foot sections of RG59U carry the video signal and vertical and horizontal deflection voltages. A separate line carries the audio signal

need for a sync separator, vertical oscillator or horizontal oscillator. The complete circuit of a slave remote is shown in Fig. 3.

The two 6SN7 tubes are operated as two-tube paraphrase vertical and horizontal deflection amplifiers feeding the appropriate plates of the cathode-ray tube. Sawtooth pulses for the two amplifiers are supplied from the cathode circuits of the deflection amplifiers in the receiver (or from the independent master remote).

The values shown in the schematic provide a raster whose corners just touch the periphery of the cathode-ray tube screen in the slave remote when the width and height controls of the master unit are adjusted for that condition. Different types of picture tubes that operate at higher or lower voltage would require slightly different sweep voltages to fill the screen. To minimize changes in the original receiver, it is best to vary only the values of components in the slave unit. In operation, the size of the slave picture varies directly with change in size of the master unit.

Four controls are provided on the front panel of the slave viewer. These are focus, contrast, brightness and audio gain. The vertical and horizontal centering controls are mounted at the rear of the chassis.

Figure 4 shows the connections of the cables to the deflection amplifiers in the receiver. Most commercial receivers have similar circuit arrangements of the deflection amplifiers. The cathode circuit of the first vertical amplifier usually contains a resistor that can be utilized as the load feed to the remote amplifier.

Usually the horizontal amplifier has the tube cathodes grounded, and a resistor is inserted as the cathode load. The values shown were found optimum for the par-

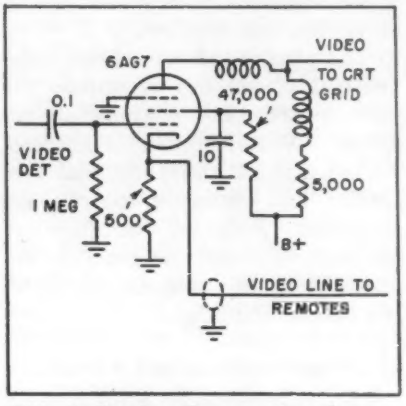


FIG. 2—Low-impedance output for remote viewers is obtained from the cathode load resistor of the video amplifier

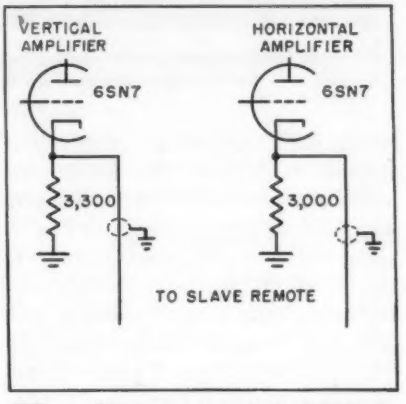


FIG. 4—Changes in receiver circuits to provide sawtooth output for the deflection circuits in the slave viewer

ticular receiver; others that use 6SL7 tubes will probably require a different value.

In some receiver designs, the second tube of the paraphase may have a cathode resistor which can be used without change. Since this tube is handling the opposite phase of the first, the slave viewer would then produce a mirror image of the picture. Reversing the deflection plate connections to the coupling capacitors of the slave unit will then give the proper image at the remote.

Deluxe Ten-Inch Viewer

It was felt that a larger and perhaps brighter picture unit was the next step. This need was quite adequately met by the General Electric 10FP4 picture tube, and an independent electromagnetic remote viewer using it was constructed. The circuit of this unit is shown in Fig. 5.

The blocking oscillator transformers and focus and deflection coils are RCA components and their circuits are the ones recommended for these parts, although the tube line-up is different from that employed in the RCA receivers.

Like the independent seven-inch viewer, the ten-inch remote contains a single-stage combined video amplifier and d-c restorer. Sync pulses are taken from the video cable by the 6SK7 sync separator at the left in the schematic diagram. Some misgiving was felt initially at the use of this simple grid-leak biased pentode circuit, but it has proven quite satisfactory.

The focus coil is arranged in the positive low-voltage line for convenience in mounting the filter capacitors. The plate current requirement of all tubes in the viewer is 150 milliamperes.

If the audio stage (not shown) is omitted, the values of the resistors shunting the focus coil may need to be changed and a bleeder resistor may be necessary in the power supply to keep the current through the coil sufficient for focusing.

Damping resistor *R* can be composed of a fixed resistor of 5,000 ohms and a rheostat of 3,000 ohms. Less than 5,000 ohms causes the picture to fold back on itself at the left side. A value upward from 5,000 ohms controls trace linearity of the left side of the picture.

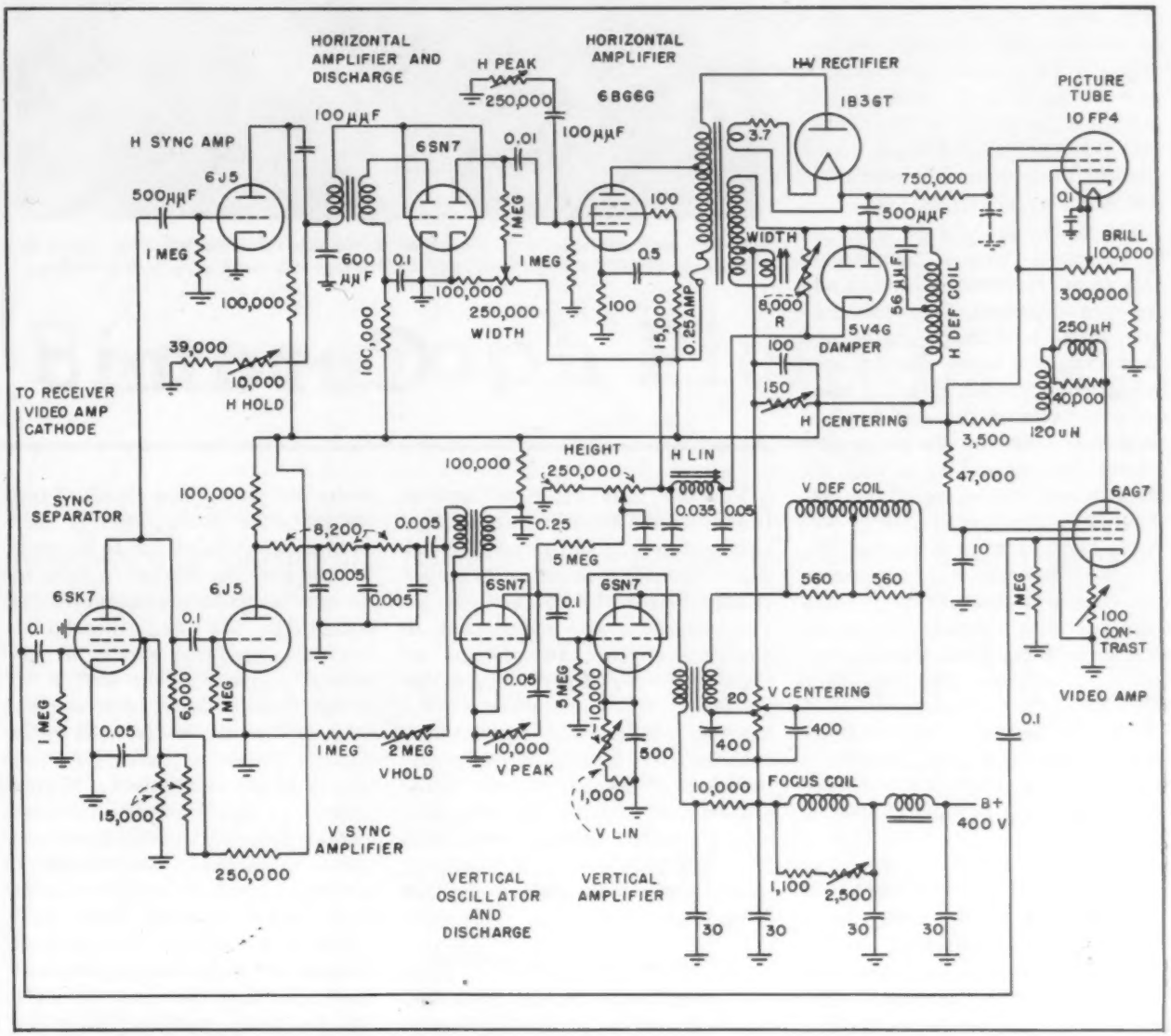


FIG. 5—Complete circuit of ten-inch independent remote viewer with electromagnetic deflection and focus

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and

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To test each cartridge, it is placed on a vibrating platform which is driven in frequency across the audio spectrum. Oscilloscope and meter show pickup response

Ceramic

SEVERAL YEARS AGO, an investigation was begun in these laboratories of newly developed high dielectric materials. Potential use in capacitors for hearing aids was envisioned. As a result of this study it was predicted that some of the materials might show piezodielectric properties while under the influence of a direct-current polarizing field. The junior author, with the assistance of Joseph Crownover, then with this company, made an experimental study of the prediction. This work disclosed that such piezodielectric properties did exist and, furthermore, that permanent polarization remained, giving some of these materials permanent piezoelectric properties.

The application of such materials to numerous types of transducers such as microphones, vibration and pressure detectors, frequency-control units, modulation units and phonograph pickups was at once indicated. A project covering these and other related items of development was started. To make this project self-supporting it was decided to exploit the use of the material in a phonograph pickup cartridge at the start. A part of the general research was concerned with an investigation of various materials which showed the piezoelectric property from the point of view of picking out a material that represented the best combination of sensitivity, freedom from temperature variation and ease of handling. The material finally chosen was barium titanate in the form of a ceramic.

Properties of Barium Titanate

The property of permanent piezoelectricity for the materials studied occurs at temperatures below the Curie point. The Curie point corresponds to a maximum point in the dielectric properties of the material. For the case of pure barium titanate this temperature is approximately 120 C. Sensitivity of the material shows negligible change between −70 and +70 C. The material is also independent of humidity effects. In addition to these properties of permanence, the material also lends itself to a symmetrical construction which contributes to the flatness of frequency response of a transducer. This property, in combination with permanence under varying conditions of temperature and moisture, makes it an ideal material for use in phonograph pickups.

Pickup Characteristics

A phonograph pickup cartridge was developed which gives a nominal output of 0.75 volt at 1,000 cycles per second on a standard test record. The construction is such as to permit this pickup to be made for the low-cost market in spite of its excellence in performance and durability. The standard cartridge originally produced carries a permanent sapphire needle with a tip of 0.0027-inch radius. The compliance of the device is sufficiently high to permit a tracking weight of only 22 grams for use on 78-rpm records. (This cartridge has been used in large quantities in phonographs marketed by Sears Roebuck & Company for considerably more than a year under the trade name Syntronic. Pickups are marketed directly by the Sonotone Corporation under the trade name Titone.)

The ceramic material is cut in narrow strips, the sides of which

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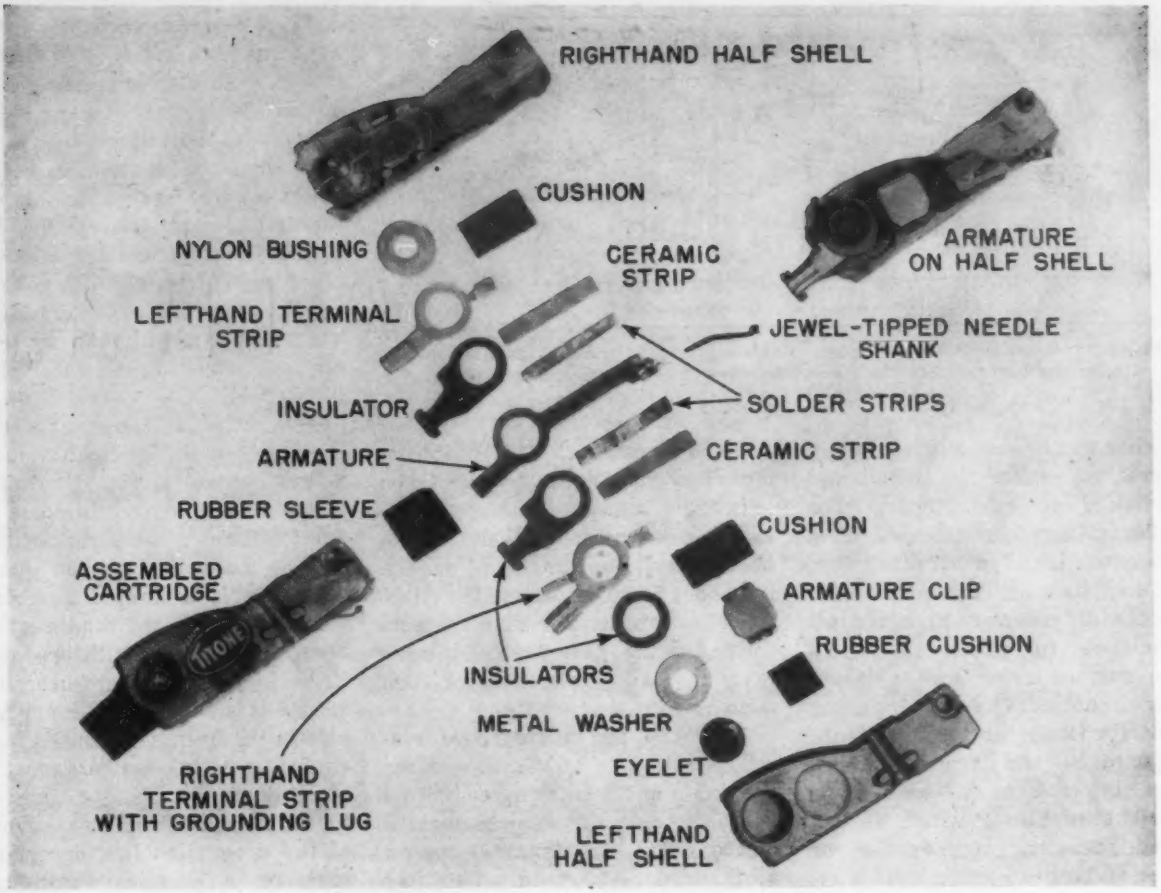


Parts of the ceramic pickup for 78-rpm records are shown in their order of assembly. The sensitive element of the pickup is formed by the two ceramic strips that are soldered to the armature. Terminal strips and cushions hold it in shell

Phonograph Pickup

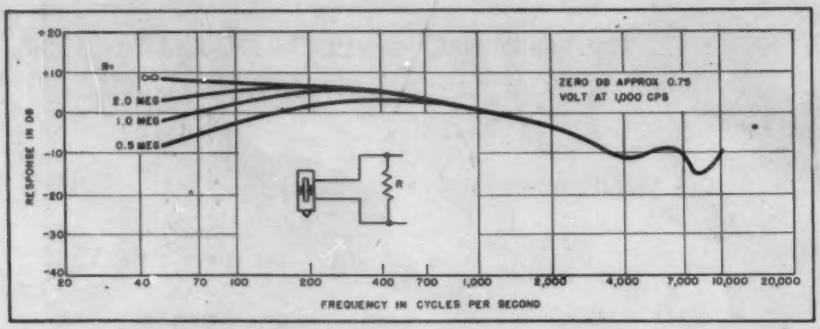
Two synthetic barium titanate slabs are mounted between three electrodes and then made piezoelectric by applying high voltage to form a pickup that is unaffected by humidity or normal temperatures. The artificial piezoelectric is generally applicable as a transducer

are covered with a silver frit. Two such pieces are fastened by soldering to the opposite sides of a thin metal armature. One end of the armature is clamped in the case, forming a hinge. To the other end is soldered a small metal arm carrying the sapphire needle. Plastic pads on either side of the assembly act as lateral dampers and control the compliance. Practically, there is an optimum thickness of the barium titanate ceramic which is a compromise between a thin strip for high capacitance, high compliance and low mass on the one hand and a thick strip for ease in handling and freedom from dielectric breakdown because of effects of surface roughness during polarizing on the other hand. Theoretically, thin strips would be best as there would then be more strain energy stored in them to produce the piezoelectric voltage.

Compliance, Inertia and Damping

At low frequencies, compliance (the reciprocal of stiffness and the mechanical analog of capacitance) is of primary importance. The ratio of the distance from the center of effective force of the plastic dampers to the hinge and from the needle tip to the hinge forms a step-down lever so that large motions at small force (high compliance) on the needle produce less motion but large force (low compliance) on the ceramic element. This arrangement is necessary, the compliance of the titanate structure being too low to drive directly.

In designing a pickup, one wants a high needlepoint compliance for



Frequency response of pickup for 78-rpm records is substantially flat at low frequencies despite small size of sensitive element because of its high dielectric constant

tracking at low frequencies, but in general the higher the compliance, the lower the sensitivity. The needle is therefore mounted on a short extension to give a reasonably high compliance. This extension is also used to give very high vertical compliance to provide freedom from surface noise and to lessen vertical shock. The proportioning of inertia (inductance), compliance (capacitance) and damping (resistance) is such as to give good transient response, which is required for clear reproduction of speech and music.

High-frequency response is provided by coupling the 7,000-cps needle-arm mode with that of the lowest mode of the system, which occurs at 2,000 cps. The provision of sufficient damping in the plastic pads smooths the resonances due to these modes to provide the response shown in the diagram.

Of great importance for proper tracking at high frequencies is the value of the effective mass of the pickup at the needle point. This mass is measured rather than calculated because of the many uncertainties and assumptions required in a system of distributed parameters. The measurement is made by observing the deviation in frequency, produced by the loading introduced by the pickup needle, of a reed driven electromagnetically. An inertia of four milligrams was measured at 10,000 cps.

The production pickup for 78-rpm records, tested on the 1,000-cps band of a standard test record, gives an open circuit output of 0.75 volt; it has a lateral compliance of 0.5×10^{-6} cm per dyne or better. The active material in the pickup has an effective dielectric constant of 1,200, giving a total internal electrical capacitance of about 900 $\mu\mu$f. The internal generator voltage is directly proportional to the needle excursion amplitude plus a lift above 5,000 cps due to the effect described above. For nominal performance the pickup should work into a load resistance of one megohm.

A pickup for microgroove records, with a 0.001-inch radius needle tip and a tracking weight of 6 grams using the same materials, develops 0.25 volt at 1,000 cps on a standard test record. This 33⅓ rpm pickup has a compliance of 0.75×10^{-6} cm per dyne. Models have also been made of a dual cartridge for playing both 78 and 33⅓-rpm records.

Manufacture of the Pickup

In describing the design and response of the pickup, its general construction was outlined. The accompanying labeled parts-view photograph indicates the construction of the pickup for 78-rpm records. The barium titanate used in the sensitive element is in the same class as that used commercially in ceramic capacitors, although the purer it is the better. Strips for the cartridge are cut from silver-frit coated sheets and solder-sweated onto the metal support. The metal wets the ceramic at high temperature and, in cooling, contracts more than it, thus putting the ceramic strips under longitudinal compression. The titanate is brittle, but by thus placing it under precompression, the assembled element can be handled safely during production and is negligibly subject to damage from rough handling in use.

The ceramic is then polarized by applying high voltages to the electrodes. Polarization takes a fraction of an hour, the exact time depending on the voltage used. (However, some combinations of ceramic materials are very sluggish, even taking days to polarize.) Inasmuch as the barium titanate breaks down above approximately 100 volts per mil the charging voltage is limited by breakdown, although for rapid production the highest safe voltage is desirable.

After the units are polarized, they are tested for sensitivity. The pickup is then assembled and finally tested for response. In some production items a sampling technique can be used to test for quality, especially if a limited number of variables affect the final performance. However, in such production items as pickups where overall response is a function of every variable in the unit, sampling is inadequate; quality control must be maintained by checking each unit for its response. Efficient operation of the production line depends, in part, on a practically automatic means of testing each assembled pickup.

Barium titanate ceramic is a polycrystalline aggregate with a high dielectric constant. Other well known materials with comparable piezoelectric properties are Rochelle salt and ammonium dihydrogen phosphate. These latter materials are used in the form of single crystals. It would not ordinarily be expected that strong piezoelectric properties would be observed in polycrystalline aggregates of random orientation. The fact that a strong effect is observed in barium titanate ceramic may be explained on the assumption that the material exists in the form of transitional-type crystals intermediate between the ionic and valence types. It appears to be possible in this type of structure to orient the domains by means of an applied polarizing field.

The project in which the above work was accomplished is now being expanded to include a study of piezoelectric properties of single crystals of barium titanate and in their potential applications to other transducer problems.

To obtain dense, nonporous slabs of barium titanate from which highly sensitive synthetic piezoelectrics can be made, the temperature of this special kiln in which the material is fired is held constant to one part in a thousand

New Synthetic Piezoelectric Material

Pure barium titanate, fired into a ceramic, can have piezoelectric properties induced into it permanently by applying a direct-current polarizing field. The design considerations for transducer elements made with the synthetic material, its properties and production are described

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BARIUM TITANATE has been studied extensively recently because of its high dielectric constant and piezoelectric properties.[1] It is a heterogeneous, randomly oriented polycrystalline, dense ceramic.

While this material has been used for several years as a high constant dielectric, in recent months it has attracted considerable attention for use in such piezoelectric transducers as microphones and phonograph pickups. In both these applications, a double-slabbed element is strained in bender fashion so that a mechanical lever advantage is gained. This article describes the bases of these applications and the method for making the material piezoelectric[2].

Size of Transducer

In fabricating transducer elements of the size used in microphones and phonograph pickups, two ceramic sheets of the desired size are bonded together, such as by soldering, after which leads are attached. These barium titanate ceramic elements, after being sub-

APPLICATION AND MATERIAL

The preceding article described the application of a new material to phonograph pickups. This article describes the material itself in greater detail. Together, they tell an interesting story.

Barium titanate, studied during the war, was found to have a remarkably high dielectric constant so it was produced as a substitute for mica in capacitors. Later a way was found to make it piezoelectric.

With the resumption of peace-time research, the properties of this material were further studied, and ultimate use in transducers of many kinds seems likely.

jected to high electric fields, exhibit induced piezoelectric properties.

The thickness to which the ceramic is extruded is determined by the practical optimum thickness of the transducer element, which has been found to be 0.010 inch, a compromise of low compliance on the one hand and voltage breakdown strength due to corona on the other hand. That such elements can have good frequency response is illustrated in Fig. 1A. Here the calculated midband and low-frequency responses are given for several microphone elements feeding through a 400-μμf cable to a 5-megohm load. The curves, calculated on the basis of the equivalent circuit included in Fig. 1A, are given for elements of five different widths, indicated by their capacitances.

Changing the width of the element has two effects upon the response. First, an increase in width decreases the longitudinal stresses in the material and hence the midband response is decreased. Secondly, increasing the width of the element has the effect of increasing the series capacitance and thus increasing the flatness of response at the low frequencies. To illustrate this point, note that the 1,600-μμf unit has the smoothest overall response, going down to half power (0.7 volt) at 17 cps. But this flatness is gained at the sacrifice of the midband level.

If the width of the unit is too small, not only is the low-frequency response sacrificed, but the midband response drops as well. This is illustrated by the curve of the 200-μμf unit in Fig. 1A. In Fig. 2 the midband response of an element is plotted as a function of its capacitance (width) for several cable loadings. From these graphs, we can expect the 400-μμf element to give the best results.

While the curves of Fig. 1A and Fig. 2 are calculated, actual tests of the frequency-response characteristics on microphone and Glennite pickup elements in Astatic housings have been made and the results, as indicated in Fig. 1B and 1C, are comparable.

Induced Piezoelectricity

The ceramic is made piezoelectric, after it is fabricated into the transducer element, by applying a polarizing potential.

The limiting factor on the usable charging potential is the dielectric strength of the titanate material. The breakdown voltage was found to be approximately 100 volts per mil, but when corona is completely eliminated, breakdown strengths approximating 200 volts per mil are obtained. A much smaller charging potential is capable of producing almost the same degree of polarization when exerted over a longer period.

The time delay for polarization to take place and the saturation can be understood from the nature of the polarizing action. Initially, individual cubic crystals are twinned within themselves (optical axes of different domains of a crystal are at 90 degrees to each other). When the polarizing potential is applied, the domains of one orientation grow gradually at the expense of the others so that, finally, the crystal approaches a single domain. This growth of one domain and shrinkage of the other can be seen with a microscope, using polarized light. Because in polycrystalline ceramic materials the orientation of some crystals may not favor the growth of one domain at the expense of the other, not all the crystals will contribute to the overall piezoelectric effect. It is interesting to observe that a single crystal of barium titanate that has been polarized has a sensitivity one order higher than does Rochelle salt.

Figure 3A shows the dielectric constant and tan δ of the material versus temperature. It will be noted that the dielectric constant is quite uniform through the normal temperature range. Figure 3B shows the piezoelectric modulus (sensitivity) over the temperature range from −60 to +140 C. There is a drop in sensitivity at low temperature (not shown) due to the lowering of the dielectric constant. The piezoelectric effect is lost if the material is heated above the Curie point, represented by the peak in the dielectric constant shown in Fig. 3A. The peak occurs at about 248 F, (120 C), therefore the maximum practical operating temperature has been found to be

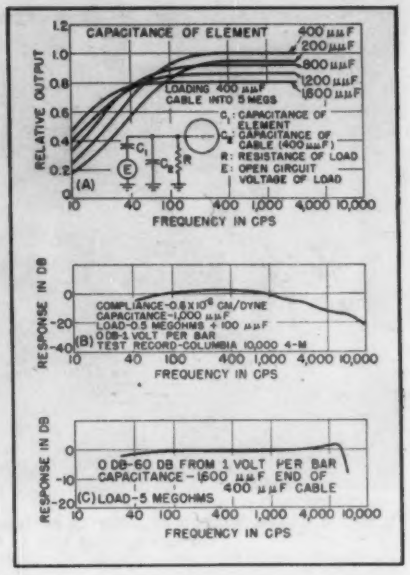

FIG. 1—(A) Capacitance of ceramic element affects theoretical frequency response, but if the optimum thickness and area of ceramic are used, the measured responses of pickups (B) and microphones (C) made from it are uniform

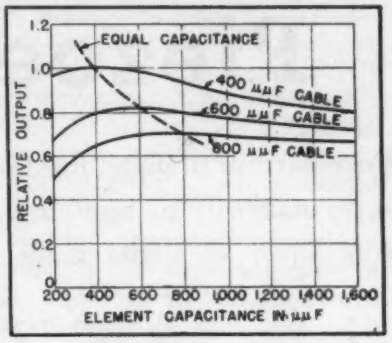

FIG. 2—For maximum midband response, the capacitance of the piezoelectric ceramic element should be made equal to that of its connecting cable

212 F, which leaves some margin.

The manner in which the relative piezoelectric sensitivity is affected by charging time is shown in Fig. 4 for a bender-type element at various charging potential gradients. The sensitivity of elements is easily determined by observing its hysteresis loop on an oscilloscope.[3]

Physics of the Phenomena

No complete theory has been advanced to explain the phenomenon of an induced piezoelectric effect. However, there does appear to be a close resemblance between the ability to produce the magnetic effects in ferromagnetic substances and these phenomena; that is, there exists small regions in which dipoles can be oriented in the same direc-

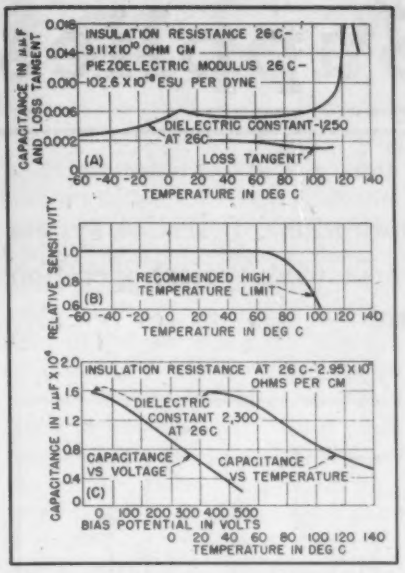
INSULATION RESISTANCE 26 C - 9.11 X 10^10 OHM CM
PIEZOELECTRIC MODULUS 26 C - 102.6 X 10^-8 ESU PER DYNE
DIELECTRIC CONSTANT 1250 AT 26C
LOSS TANGENT
(A)
CAPACITANCE IN μμF AND LOSS TANGENT
TEMPERATURE IN DEG C
RECOMMENDED HIGH TEMPERATURE LIMIT
(B)
RELATIVE SENSITIVITY
INSULATION RESISTANCE AT 26 C - 2.95 X 10^4 OHMS PER CM
DIELECTRIC CONSTANT 2,300 AT 26 C
CAPACITANCE VS VOLTAGE
CAPACITANCE VS TEMPERATURE
(C)
CAPACITANCE IN μμF X 10^4
BIAS POTENTIAL IN VOLTS

FIG. 3—Characteristics of piezoelectric ceramic are (A) dielectric constant, loss tangent and (B) sensitivity. Another type of ceramic shows nonlinear capacitance effects (C) illustrating the versatility of these new materials

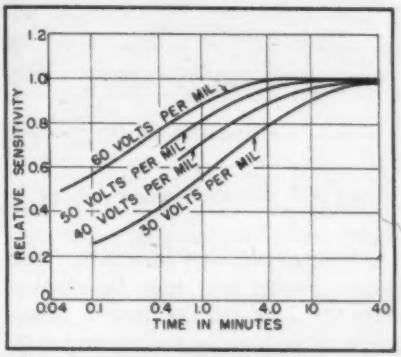

FIG. 4—Saturated polarization is reached sooner with higher potential gradients, but even small voltages polarize the material ultimately

tion under the influence of strong electric fields and these regions retain an electric moment after the externally applied field is removed.

Like all piezoelectrics, electrical charges can be generated in the sensitized barium titanate on the application of mechanical stress. However, the features which distinguish the piezoelectric ceramic material from the natural piezoelectrics are: (1) the piezoelectric effect is induced, (2) oriented cuts of the piezoelectric ceramic are not required because the material is polycrystalline and random in distribution, while in the normally accepted material, oriented cuts of single crystals are used, (3) the induced piezoelectric effect can be removed and reinduced repeatedly with no discernible deterioration of the material, (4) oppositely sensitized adjoining regions may lie within a single strip of ceramic, and (5) it does not absorb moisture.

The piezoelectric effect, due to hydrostatic pressure, has been measured and found to be on the order of 100×10^{-8} esu per dyne.

If this general phenomenon exhibited by the material can be considered as conforming to properties of certain piezoelectric materials, it means that the piezoelectric ceramic material will exhibit primary pyroelectric effects. This would place a limitation on the use of barium titanate in high power mechano-electric transducers, because application of high alternating potentials would heat the ceramic, possibly above its Curie temperature, in which event the induced piezoelectric effect would be lost. However, it can be used for low-powered devices, such as tweeters.

Producing the Ceramic

As in all ceramics, control of the composition of the raw material is highly important. However, for piezoelectric purposes this alone is insufficient. Several steps must be taken to remedy slight variations of impurities in the raw material. The necessity of processing barium titanate into thin sheets has called for a new ceramic method.

The raw materials are intimately blended by severe agitation and grinding with the vehicles and binders. The mixed suspension is then placed under vacuum to eliminate entrapped gases, which tend to lower the density and dielectric strength of materials made by typical methods.

The treated suspension is next spread evenly on a moving belt where it is dried and then removed in sheet form resembling paper. The sheets are then punched to a convenient size and are placed on highly pure ceramic tile for firing.

Firing of the ware is a step where extreme control must be maintained to obtain high-quality ceramics of uniform characteristics economically. It has been found necessary to design and build a special tunnel kiln where temperatures between 2,400 and 2,500 F can be maintained within ± 3 F.

The fired ware is then silver coated using ceramic fired-on silver. Control at this point must be maintained to apply the correct electrode thickness properly. Ceramic sheets are then cut by an abrasive wheel into the sizes required for piezoelectric applications.

It is well to note that this process can be adapted to the fabrication of capacitors and other dielectrics. Sheets from 0.003 to 0.020 inch thick can be processed up to 16 square inches in area.

An additional ceramic of considerable interest, which is not piezoelectric at room temperature, is one having a high voltage coefficient of capacitance; Fig. 3C gives its capacitance versus voltage as well as its capacitance versus temperature. This ceramic material could facilitate the construction of a sweep-frequency generator. The frequency of an oscillator can be changed by applying biasing voltages to the ceramic capacitor. It has been found that a varying biasing potential can be conveniently used to modulate an oscillator. An inexpensive sweep-frequency generator for television testing purposes could be easily made with it. Thus it can be anticipated that ceramics will play an increasingly important part in the electronic industry.[4,5]

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(2) G. N. Howatt, R. G. Breckenridge and J. M. Brownlow, Fabrication of Thin Ceramic Sheets for Capacitors, *Jour. Am. Ceramic Soc.*, p 237, Aug. 1, 1947. Apparatus, procedure and results of extruding, drying and firing thin sheets of barium titanate are described.

(3) Alexander de Bretteville, Jr., Oscillograph Study of Dielectric Properties of Barium Titanate, *Jour. of Am. Ceramic Soc.*, p 303, Nov. 1946. See also Sawyer and Tower, *Phys. Rev.*, p 269, 35, 1930.

(4) H. L. Donley, Barium Titanate and Barium Strontium Titanate Resonators, *RCA Review*, p 218, June, 1948. From measurements of polarized ceramics vibrating as resonators normally to the direction of polarization and radio-frequency fields, it is found that these ceramics have Q's of about 80 and higher, and large temperature coefficients of frequency of about one part in 400 per degree C at room temperature.

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High-Voltage Supplies

Discusses several types and their adaptability to portable applications. Describes system found to be best suited for such applications and gives curves showing typical operation under normal operating conditions

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DURING the past decade, a number of battery-operated lightweight power supplies for use with Geiger-Muller counters operating between 800 and 1,500 volts have been described, and data on their performance characteristics have been recorded. Where light weight has been the prime consideration, as for example, in cosmic-ray measuring equipment sent aloft in balloons, specially designed batteries are often required. These are of such small size that they are usually exhausted in the few hours required for a test.

For applications involving field service work, it is desirable that standard batteries be used. They must be light in weight but capable of supplying the equipment for several hours per day with intermittent use over a period of several months.

Metering

For all work with power supplies for G-M tubes, it is usually desirable to have a direct and fairly accurate indication of the voltage. In this way, the voltage may be checked with the data supplied by the manufacturer to insure that the operating point of the tube is on the Geiger plateau or level portion of the counter characteristic.

One of the simplest ways to obtain accurate voltage indication is to insert a sensitive meter in series with an accurately known bleeder resistance across the high-voltage output. With a high-voltage source of low internal resistance, such as a battery, the resistance and the meter may be switched out of the circuit except when the voltage is measured. With sources of high internal resistance, such as in portable electronic h-v supplies, the load regulation is poor and the bleeder should be in the circuit at all times during operation. The meter, however, when not being used as a voltage indicator, may be switched for use elsewhere in the apparatus, as, for example, for indicating the integrated counting rate in an amplifier circuit from the G-M tube.

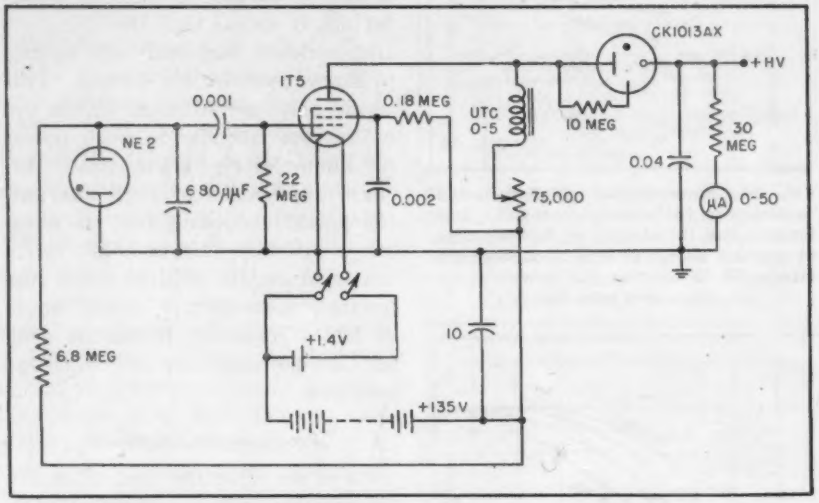

FIG. 1—Circuit of portable 900-volt power supply with adjustable output voltage

For the sake of ruggedness, a meter drawing 50 μa at full scale appears to be desirable. With high-voltage sources of high internal resistance, the use of a 50-μa meter is also preferable to a 20-μa meter because of the improvement in regulation with variable G-M tube loads.

The need for metering the high voltage and its consequent ramifications, particularly when used in circuits of high internal resistance, presents a further problem, the efficiency of power transformation. In the sense that the bleeder power is useful, in that it makes possible a necessary voltage indication, the output power may now be considered the sum of the power dissipated in the bleeder, meter, and G-M tube circuit. The power expended in the meter and G-M tube circuit is negligible compared with the power dissipated in the bleeder. A bleeder current of 50 μa at 1,500 volts represents a power output of 75 milliwatts, a requirement which has a direct bearing on the battery size for the desired life. It also points to the need for good power transformation efficiency.

For example, suppose that four midget 67½-volt batteries, each weighing 12 oz., are arranged in series-parallel to deliver 135 volts at 2.5 ma for a desired useful life of 325 hours. Suppose that at this battery input a voltage-multiplying circuit has been found that will deliver 50 μa at 1,500 volts. The efficiency or ratio of power output to power input is 22.2 percent. If the efficiency were 44.4 percent, the battery weight could be reduced from 3 lb to 1½ lb.

For G-M Counters

Midget batteries are now available up to 300 volts (Eveready No. 493). A high-voltage supply consisting of a multiple of 300-volt units has much in its favor. The units are fairly compact and extremely simple to install. The life is essentially the shelf life when used with normal G-M counter currents of less than 1 μa. Even when counting at a rate of 250,000 counts per minute, the current drawn by a small G-M tube is seldom more than 3 μa, which is still a negligible drain. Because of the low internal resistance, the metering may be done intermittently; hence there is no metering drain during operation. Disadvantages include lack of voltage variability, changes in voltage with battery age, and higher weight and replacement cost than that of some electronic circuit substitutes.

Charged Capacitors

Instead of using batteries, the possibility of storing a charge in a capacitor might be considered. Prior to taking the equipment into the field, a capacitor is charged to the desired operating voltage. Suppose that the total load and leakage current is 1 μa and the permissible voltage drop over 3 hours anticipated field use is 100 volts, and the G-M tube has a useful plateau 100 volts wide. The required capacitance is the ratio of change in charge to change in voltage ΔV. Then $C = it/\Delta V$ where i is the current and t is the time. Substituting the values from the above example, a capacity of approximately 108 μf is required.

A single voltage unit might be arranged to charge a number of capacitors in parallel and discharge them in series, thus building up the voltage to the desired value. The best method proposed has been to connect the capacitors in series, and charge each one successively by switching the battery voltage with a pair of commutators mounted on a rotating shaft. The shaft may be spring driven or motor driven. Because of the inevitable losses in switching, the resulting voltage is not an integral multiple of the battery voltage and will, of course, vary as the battery ages. This calls for voltage metering. By suitable choice of shaft speed, number of commutator sections, and capacitor values, the percent ripple and the internal resistance can be made low and the metering circuit may be removed except when a voltage reading is required.

If a battery-powered electric motor is used to drive the commutator shaft, the problem of the weight of this battery in relation to its useful life enters in. The smallest electric motor is rated at 1/2,000 h-p or 373 milliwatts. The battery supplying this motor for 325 hours intermittent service weighs almost 3 lb.

For sake of comparison with other systems, the efficiency is computed when the voltage is being metered (when there is appreciable output power). Assuming a power transformation factor for the voltage-multiplying circuit of 75 percent, and as before, that the device is supplying 50 μa at 1,500 volts, the efficiency will be 15.85 percent.

At 900-volt operation, the efficiency is only 6.6 percent. The difficulty of adjusting the voltage and the relatively high power requirements of the motor make this system a doubtful solution to the problem.

Vibrators

Considerable interest is being shown among commercial and governmental agencies in the development of small high-voltage low-power devices employing mechanically vibrating reeds. These vibrators normally operate from a battery supplying 1½ to 6 volts. The high voltage is obtained by the rapid collapse of the magnetic field produced in a transformer supplied by the same battery. The voltage is readily controlled by a series variable resistor in the low impedance side of the transformer.

One type of vibrator supply is reported to deliver 50 μa at 1,100 volts with an input drain of 250 ma at 3 volts. A battery delivering this input intermittently for 325 hours weighs 5 lb 10 oz. The power transformation efficiency is 7.34 percent.

Vibrator-type power supplies for

TABLE I—Comparison of Portable High-Voltage Power Supplies

Type	Limitations for Portable Use
Straight Battery Operation (Using Eveready 300-volt midget batteries)	No voltage variability. Voltage changes with battery age. Heavy. Replacement cost high
Charged Capacitor (Large capacitor charged to desired voltage prior to taking equipment into field)	Leakage current causes voltage to drop between time charged and time when unit is used. Large capacitor needed (over 100 μf). Bulky, expensive, and annoying to charge before use
Capacitors in Series (Charging capacitors in parallel with low voltages and discharging them in series for desired high voltage)	A motor-driven switching system is required, with accompanying motor power requirements. Low efficiency at desired voltage. Discharge voltage depends on condition of charging battery. Switching losses
Vibrators (Vibrating reed causes periodic collapse of magnetic field in transformer)	Heavy low-voltage battery. Low power transformation efficiency for high-voltage low-power applications. Bulky
R-F Power Supply (High frequency feeding into step-up transformer)	Transformer losses. Low overall efficiency

automobiles have an efficiency between 60 and 75 percent. Unless the efficiency of the high-voltage low-power types can be made 15 percent or more, metered power supplies of light weight and relatively long battery life are not very practical by this method.

R-F Power Supplies

High-voltage r-f power supplies for cathode-ray tubes have been in use for some years and it is natural to consider the applicability of this type for portable G-M counters. Again the efficiency is the prime consideration.

In the r-f type of power supply, a feedback oscillator drives the primary plate coil closely coupled to a larger secondary coil.

A commercial coil unit was tried in a circuit employing a 1U4 oscillator and a CK1013AX cold-cathode rectifier. It became apparent that the rectifier did not perform properly in the frequency ranges tested, 80 to 400 kc. A filamentary type rectifier, a type 1654, performed satisfactorily, but the best B-battery efficiency secured was only 13.4 percent. A coil combination made from commercially available chokes gave approximately the same efficiency.

The chief source of loss occurs in the secondary winding. In order to keep the losses in the secondary small, the equivalent parallel resistance of the secondary at resonance must be large compared with the load resistance. As the output load is to be 30 megohms, the secondary must have at least this resistance. Quoting from an article by O. H. Schade (see bibliography), " . . . secondary circuits of such high impedance are too expensive and large for practical use."

If a sawtooth voltage is applied to the grid of a vacuum tube in the plate circuit of which there is a high inductance choke, the rapid changes in plate current induce large voltages across the winding in the choke. This induced fluctuating voltage may be rectified and smoothed to provide high d-c voltages.

As an alternative, a cold-cathode grid-controlled thyratron is arranged so that the RC-derived voltage periodically gains control and cuts off the plate current. This would have the great advantage of requiring no filament battery supply. Unfortunately, experiments with a CK1089 tube indicated that stable oscillations could not be secured with less than about 500 milliwatts input.

A blocking type of audio oscillator was also tried, using the secondary of the transformer in the plate circuit and the primary as tickler feedback in the grid circuit. The efficiency of this system was relatively low.

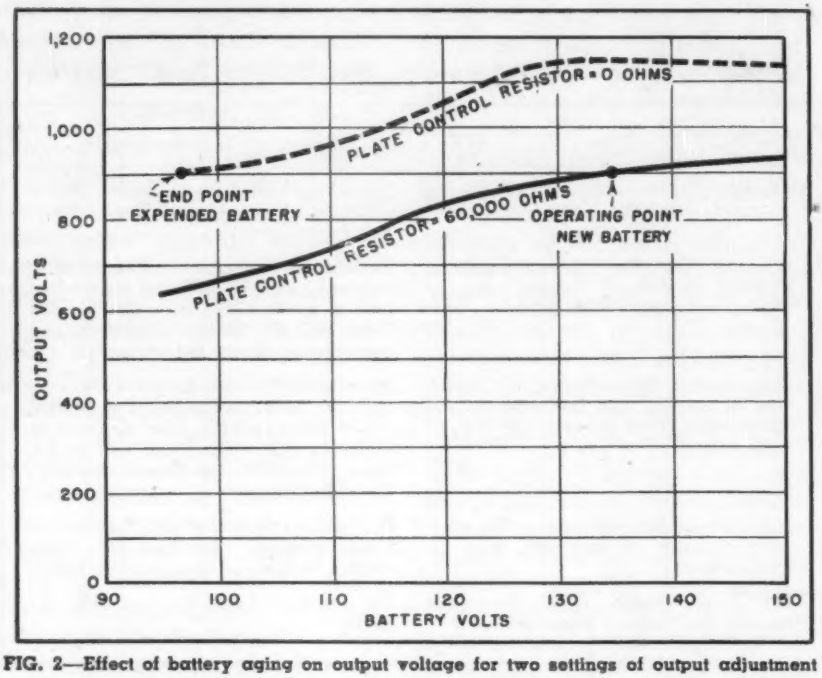

FIG. 2—Effect of battery aging on output voltage for two settings of output adjustment

Another way to generate a suitable sawtooth voltage is by means of a multivibrator. A pair of vacuum tubes, resistance and capacitance intercoupled, operate in a free-running flip-flop arrangement and the voltage developed in the output circuit of one tube drives the amplifier. Subminiature tubes of low power drain are excellent.

Neon-Controlled Oscillator

A very simple method which provides slightly better overall efficiency than the multivibrator is to use a neon bulb supplied through a resistor from the B-battery supply and shunted by a suitable capacitor. The sawtooth is generated by the voltage rise across the capacitor and sudden drop when this voltage reaches the ionization potential of the gas.

The proper choice of iron-core choke in the plate circuit is usually found by trial and error. Commercially available interstage audio transformers are often used with primary and secondary connected in series aiding. There is a marked difference in the performance of units supplied by different manufacturers, even among units whose design characteristics for their originally intended purpose are the same.

A rectifier capable of withstanding at least 2,000 inverse peak volts is desirable. In the unit to be described, the CK1013AX cold-cathode gas rectifier is efficient and has the advantage that no filament battery is needed. Voltage is supplied to the starter electrode through a 10-megohm resistor.

Where voltages over a wide range are required, a convenient control is to use a series variable resistor in the screen grid circuit of the output tube. In this way, variable voltages can be obtained at maximum efficiency.

A number of experimental circuits employing a neon-controlled oscillator operating at audio frequencies and driving a 1U4 or 1T5 were tried. For obtaining 1,500 volts or more, about 200 volts plate supply is required in addition to the 50 ma at 1.4 volts drawn by the filament. At 1,500 volts, an overall power transformation efficiency of 22 to 23 percent is normal. At

lower output voltages, the filament power drain is a larger factor and consequently the overall efficiency is less.

900-Volt Power Supply

Figure 1 is the circuit used for a 900-volt supply and on which the performance curves of Fig. 2 and 3 are plotted. In this case, the objective was a single-control constant-voltage supply that could be compared for cost and weight with three 300-volt batteries. The control is necessary in order to adjust for the slow drop in voltage over the useful life of the two midget 67½-volt plate and neon supply batteries.

The frequency is determined by the time constant of the RC combination in the neon supply circuit, by the particular characteristics of the plate-circuit choke, and to a lesser extent by the supply voltage. The choke is a UTC 0-5 hearing-aid transformer with primary and secondary connected in series. The NE-2 neon bulb may be replaced by a NE-51, which is a based type of identical characteristics. In operation, the neon bulb glows sufficiently to act as a pilot light. Its characteristics do not appear to change with use. A half dozen NE-2 and a couple of NE-51 bulbs have been tried in the circuit with inappreciable differences in response.

In order to keep the battery drain over its useful life at about 1.1 ma or less, the output voltage control was placed in the plate circuit and the values of the screen dropping resistor and by-pass capacitor were adjusted until satisfactory operation was secured. The effect of battery aging on the output voltage at two settings of the variable resistor is plotted in Fig. 2. The introduction of resistance in the plate circuit decreases the efficiency of the circuit when a new battery is inserted. As the batteries age, the setting is advanced and the efficiency increases, permitting operation at 900 volts output over a fairly wide range in battery voltage. The overall power transformation efficiency at the 900-volt operating point when the batteries are new is 13.2 percent. For expended batteries (decreased to 97 volts), the overall efficiency is 17.0 percent.

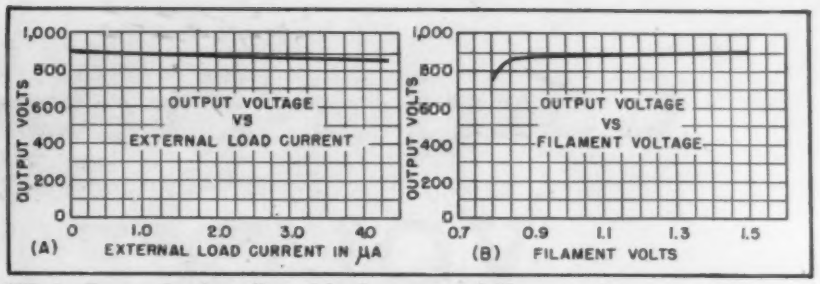

FIG. 3—Curves showing effect of load current and filament voltage on voltage output

Fig. 3A shows the output voltage regulation as a function of the external load, as would be produced by a G-M tube operating at high counting rates. This would be considered adequate for a G-M tube having a normal flat-plateau characteristic. If the G-M tube does not have a flat plateau, the voltage is returned to the proper operating potential by adjusting the resistance in the plate circuit. Such readjustment would be necessary only at counting rates of several hundred thousand counts per minute.

Battery-Aging Effects

The effect of changing filament voltage on output voltage is given in Fig. 3B. The data recorded was taken at 135 volts battery supply. At 105 volts battery supply, the curve is similar with very little change in output voltage as the filament battery decays from 1.5 to 0.8 volt.

A 0.04-μf capacitor was selected for convenient physical size and low cost as output smoothing capacitor. With the circuit delivering 900 volts the ripple is 0.3 volt.

The weight of all the components of Fig. 1 including batteries is 2.1 lb. Three 300-volt batteries weigh 2.8 lb. The two 67½-volt batteries in the circuit may be used as low-current plate supply in associated amplifier circuits fed from the G-M tube. With a 900-volt battery pack, an additional low-voltage battery is required for the pulse-amplifying and recording circuits, adding another 0.7 lb to the weight of the battery pack system. The total cost of components is very nearly the same as the cost of a 900-volt battery pack. On the other hand, the battery replacement cost for the neon-oscillator circuit is about one quarter of the total replacement cost for the battery pack system.

Available literature on 67½-volt midget battery characteristics indicates that the circuit of Fig. 1 should operate 300 hours at 6 hours per day intermittent use before the batteries must be replaced. The unit was tested continuously for 126 hours at 900 volts output without failure.

The high peak voltage which appears across the plate of the output tube suggests the possibility of early tube breakdown. A circuit similar to Fig. 1, but using the miniature type 1U4 tube and higher plate and screen voltage, delivered 1,900 volts output for several hours without evidence of voltage breakdown. Nevertheless, with a d-c voltage source, three type 1U4, with plate and screen connected together and tested at grid bias sufficient to limit the current to 1.0 ma, broke down between 1,500 and 1,700 volts. Apparently, the tubes withstand higher instantaneous voltages than would be indicated by tests made under static conditions.

In conclusion, the author wishes to extend his grateful acknowledgment to R. P. Ghelardi for his helpful counsel and encouragement during the course of this investigation.

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Carrier-Frequency VOLTMETER

Strength of signals received over power lines, telephone lines and cables in the range between 20 and 500 kc is directly indicated in db, using a fixed-gain double-superheterodyne receiver. A built-in calibration oscillator is provided

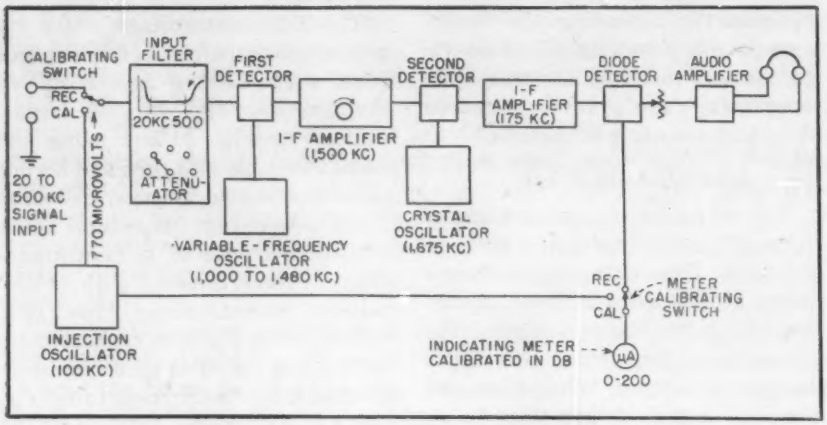

FIG. 1—Functional block diagram

By PAUL BYRNE

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Belmont, California

THE carrier-frequency voltmeter to be described was developed primarily for making measurements on power lines, telephone lines and cables in the region between 20 and 500 kc. The specifications to which the instrument performs are based on the requirements of the Pacific Gas and

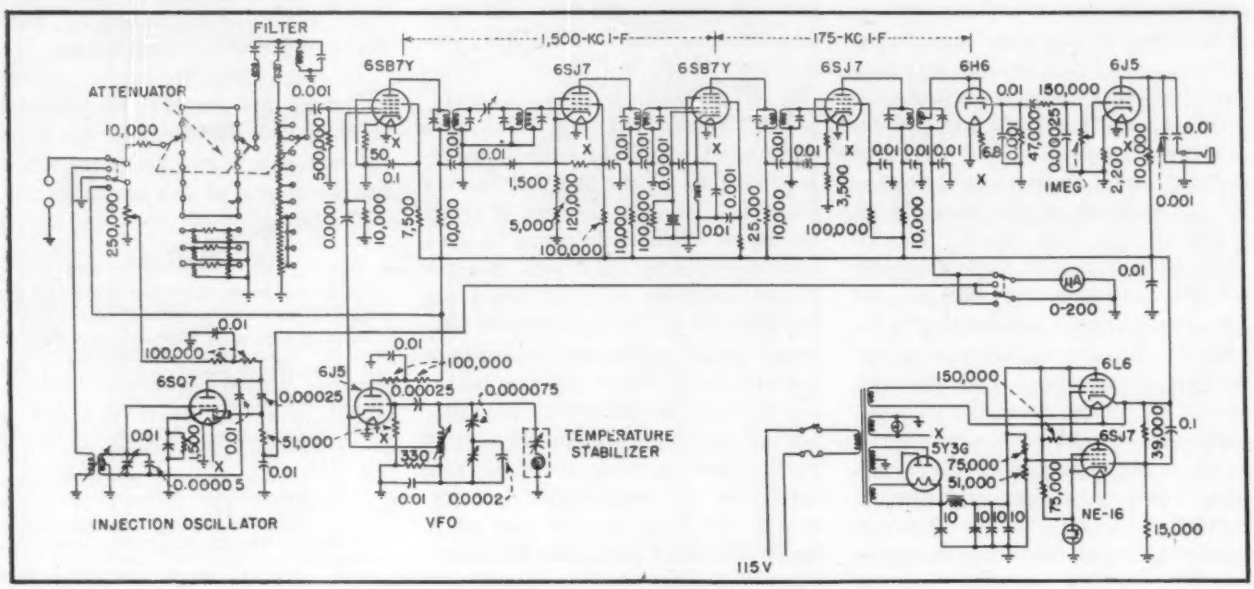
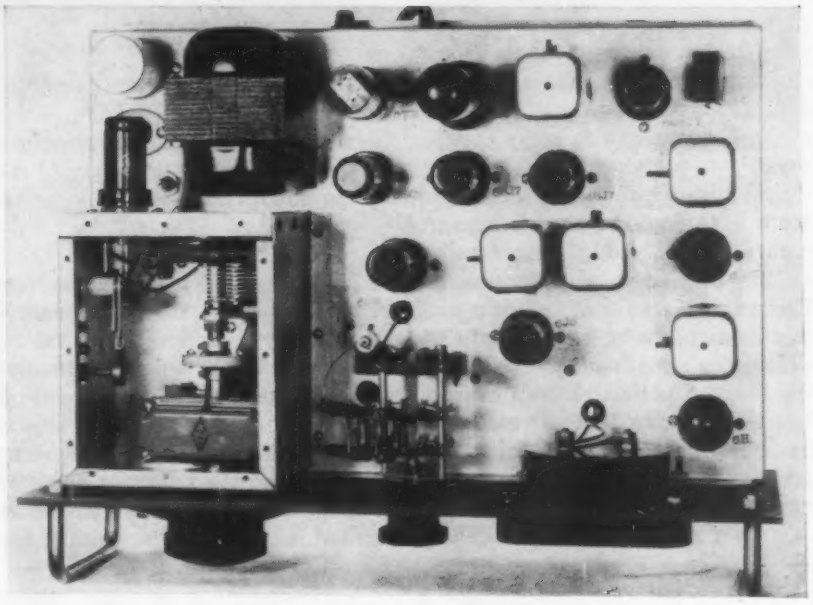


FIG. 2—Complete circuit diagram of the instrument

The carrier-frequency voltmeter



Internal construction of the instrument

Electric Company. Special features were suggested by engineers of the Bell Telephone System.

The instrument is essentially a fixed-gain double-superheterodyne radio receiver covering the required frequency range. The d-c output of the final detector operates a microammeter calibrated in db. A variable attenuator, connected between the input terminals and the first grid, provides a wide range of measurable voltages. An injection oscillator, in effect a signal generator, is included to facilitate calibration.

Circuit Details

Referring to the block diagram of Fig. 1 and the complete schematic of Fig. 2, the input filter is of the bandpass variety. The attenuator consists of a wire-wound section and a carbon-resistor section, and operates in 10-db steps.

The variable-frequency oscillator beats with incoming signals in the carrier-frequency range and produces a 1,500-kc signal at the input of an adjustable-gain i-f amplifier. Temperature stabilization of the vfo is accomplished by means of a variable capacitor consisting of two fixed plates about $\frac{1}{4}$ inch by $1\frac{1}{2}$ inches in size and an intermediate movable plate operated by a $2\frac{1}{2}$-turn spiral of thermostatic bimetal. The output of the 1,500-kc amplifier combines in a second detector with that of a 1,675-kc crystal oscillator to produce a 175-kc signal which is fed to a fixed-gain i-f amplifier. Output of the 175-kc amplifier goes to a third detector. The audio output of this detector drives an a-f amplifier operating a headset used for monitoring. The d-c output of the third detector operates the indicating meter, which is a 0-200 microammeter.

The injection oscillator delivers 0.77 volt (0 db) to the input circuit of the instrument, operating at 100 kc. A switch permits the output of the injection-oscillator monitoring diode to be read on the indicating meter for calibration purposes. Adequate signal input is provided so frequency calibration of harmonic points above 100 kc on the dial can be checked from the injection oscillator.

Performance Characteristics

The carrier-frequency voltmeter will handle from 77 microvolts to 77 volts at the input, or 80 db below to 40 db above zero level (1 milliwatt into 600 ohms). Selectivity characteristics are approximately 6 db down at 1 kc off resonance, 18 db down at 3 kc off resonance and 40 db down at 7 kc off resonance.

Input impedance is 10,000 ohms in the rejection band, and approximately 20,000 ohms in the pass band.

Multichannel Radio

Developed to transmit cosmic ray and other high-altitude data, the Aerobee telemetering system combines a high degree of flexibility and package design with light weight and small volume. Uses special circuits for transmitting voltage and pressure data

By GENE H. MELTON

Applied Physics Laboratory
The Johns Hopkins University
Silver Spring, Maryland

RECENTLY publicized work in high-altitude research has been highlighted by the development of the 3,000-mile-per-hour Aerobee sounding rocket. In order to collect data for high-altitude studies, a telemetering system with a high degree of flexibility, light weight, and small volume was needed.

One purpose of the Aerobee program is to measure cosmic rays at high altitudes, using Geiger tubes as the primary end instruments. These tubes feed scaling-down and thyratron circuits, the outputs of which consists of negative pulses of short duration and random timing. The telemetering system must then transmit these pulses as faithfully as possible and record them as a function of the cosmic rays.

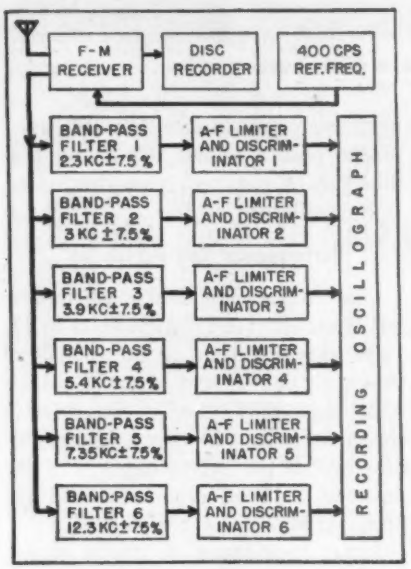

F-M RECEIVER
DISC RECORDER
400 CPS REF. FREQ.
BAND-PASS FILTER 1 2.3 KC ± 7.5 %
A-F LIMITER AND DISCRIM-INATOR 1
BAND-PASS FILTER 2 3 KC ± 7.5 %
A-F LIMITER AND DISCRIM-INATOR 2
BAND-PASS FILTER 3 3.9 KC ± 7.5 %
A-F LIMITER AND DISCRIM-INATOR 3
BAND-PASS FILTER 4 5.4 KC ± 7.5 %
A-F LIMITER AND DISCRIM-INATOR 4
BAND-PASS FILTER 5 7.35 KC ± 7.5 %
A-F LIMITER AND DISCRIM-INATOR 5
BAND-PASS FILTER 6 12.3 KC ± 7.5 %
A-F LIMITER AND DISCRIM-INATOR 6
RECORDING OSCILLOGRAPH

FIG. 1 —Block diagram of ground-station equipment which receives and records telemetered information

Additional requirements imposed upon the system include measurements of several different pressures in the missile, and a variety of d-c voltages, both positive and negative.

The Telemetering System

The basic telemetering system now being used is of the frequency-division type, utilizing six audio subcarrier bands whose oscillators are frequency-modulated by end instruments actuated by the intelligence to be transmitted. Frequency response for the bands is approximately 60 cps and is presently limited by the response time of the recording galvanometers used.

A method of measuring higher frequency components lies in the use of a multivibrator oscillating at 50 kc, which is frequency-modulated by the signal voltage. Response of this unit is good to 10 kc. The output of this oscillator modulates the radio transmitter directly and, for recording, a 50-kc discriminator is employed, the output driving a recording-camera-type oscilloscope. Frequency and amplitude may be read from the film obtained from this method.

The subcarrier oscillators are designed to be used in any band and give a varying frequency output as a function of the input intelligence. The simplest type of oscillator, for measuring pressures, utilizes an iron-core coil whose inductance is varied by a mu-metal slug attached to a flexible diaphragm to which the varying pressure is applied. Other types of oscillators are more complex in order to measure such variables as temperature, voltage and strains, but all perform in the same manner to give a frequency-modulated audio signal.

The outputs of the oscillators are adjusted to proper level, mixed together through an isolating network, and the complex voltage is applied to the grid of a reactance tube in an f-m transmitter, giving direct frequency modulation.

The ground station equipment for recording the transmitted signal consists of an f-m receiver, a set of audio discriminators, and a multichannel recording oscillograph. The receiver detects and demodulates the transmitted signal in normal f-m fashion, and the complex audio output is applied to a set of filters in the audio discriminators. These filters are of the band-pass type tuned to cover the respective subcarrier bands and have substantially flat-topped response inside the band, with steep skirts at each end. Each filter output is then passed through limiter and clipper stages and is fed to a tuned audio discriminator whose output is linear with frequency. A cathode-coupled push-pull power output stage drives a string in the oscillograph for the actual photographic record. A block diagram of the ground station equipment is shown in Fig. 1. Auxiliary equipment in the ground station includes a large disc-recorder for simultaneous recording and interpolation oscillators for calibrating the audio discriminators.

Telemetering for Rockets

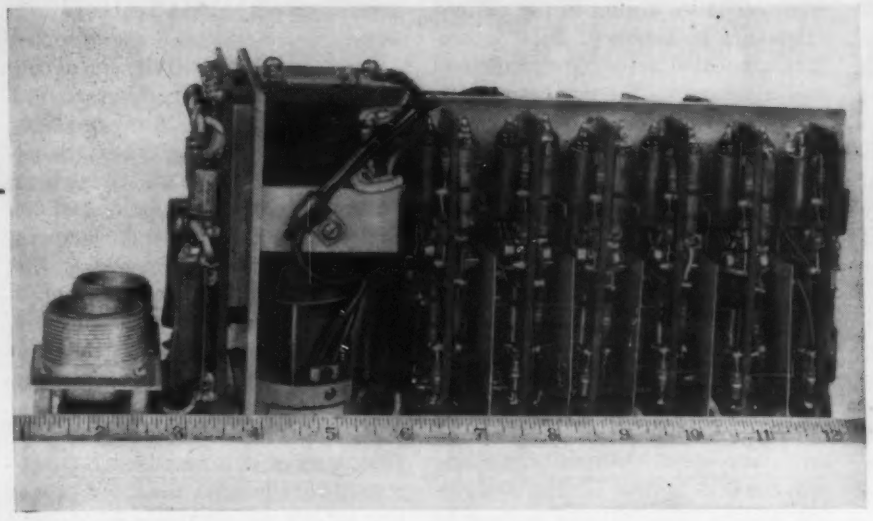


FIG. 2 —Back view of audio case showing commutating switch and voltage-controlled oscillator. This unit weighs about 5 pounds

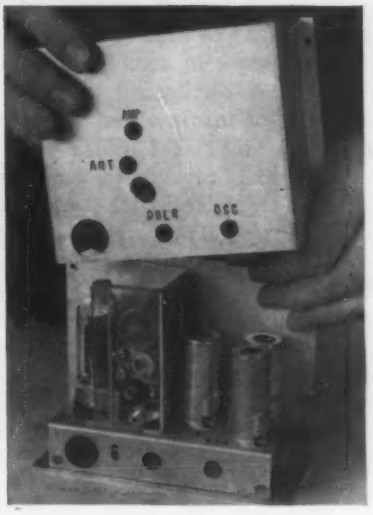


FIG 3 —Front view of r-f portion of the telemetering transmitter

The Aerobee telemetering system, as supplied to the user group, is broken down into two parts: the audio case and the r-f transmitter. These units are mounted separately in the missile and are connected by a cable.

The audio case is of aluminum construction, occupies a volume of 281 cubic inches and has a maximum weight of five pounds. The use of commutation and switching of oscillators increases the amount of data which may be transmitted and a maximum of fourteen oscillators is provided for in the unit. A complete audio unit is shown in Fig. 2.

The transmitter is also of aluminum construction, has a volume of 60 cubic inches and weighs 1½ lb including cover and mounting plate. Figure 3 shows a front view of the transmitter. Excitation of the missile is employed to radiate the r-f signal and is accomplished by means of an insulated spike mounted in the nose. A slug-tuned loading coil couples the spike to the transmitter through a coax cable.

Power for telemetering is supplied from the missile power supply system, consisting of 28 volts of storage battery driving a bank of dynamotors, with three allotted to telemetering. These dynamotors furnish approximately 220 volts at 60 ma, although one may give as high as 400 volts to supply the transmitter final stage. Filament supply is taken from an 8-volt tap on the main battery and is adjusted to 6 volts by a resistor.

Audio Chassis

Three types of audio systems have been produced to date, with different electrical requirements for each one. Figure 4 shows the block diagram of the unit used in recent tests. Provision for the separation relay and commutating switch is included in all types and may be left out if not needed for the particular application at hand.

Two basic types of subcarrier oscillators are used: the TOL-1A inductance oscillator for pressure measurements, and the TOE-1A voltage-controlled oscillator for voltage measurements, including cosmic pulses. These units are dimensioned in a multiple system of

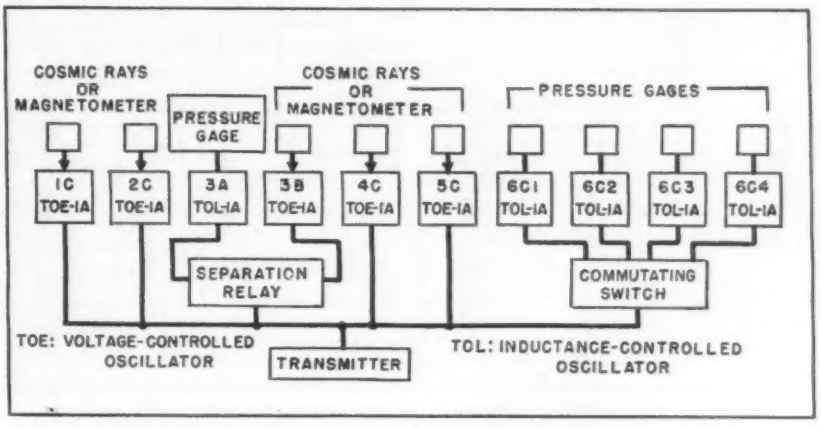


FIG. 4 —Block diagram of audio case used in recent Aerobee flights

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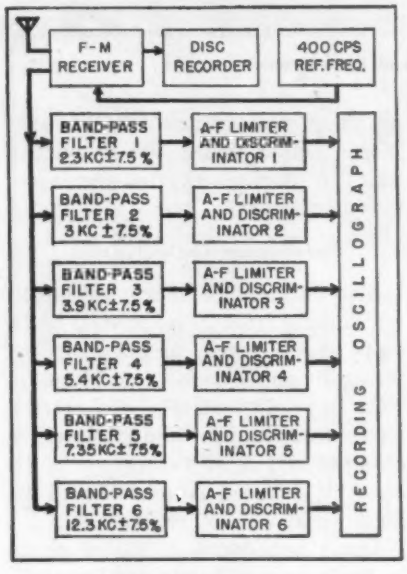
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The subcarrier oscillators are designed to be used in any band and give a varying frequency output as a function of the input intelligence. The simplest type of oscillator, for measuring pressures, utilizes an iron-core coil whose inductance is varied by a mu-metal slug attached to a flexible diaphragm to which the varying pressure is applied. Other types of oscillators are more complex in order to measure such variables as temperature, voltage and strains, but all perform in the same manner to give a frequency-modulated audio signal.

The outputs of the oscillators are adjusted to proper level, mixed together through an isolating network, and the complex voltage is applied to the grid of a reactance tube in an f-m transmitter, giving direct frequency modulation.

The ground station equipment for recording the transmitted signal consists of an f-m receiver, a set of audio discriminators, and a multichannel recording oscillograph. The receiver detects and demodulates the transmitted signal in normal f-m fashion, and the complex audio output is applied to a set of filters in the audio discriminators. These filters are of the band-pass type tuned to cover the respective subcarrier bands and have substantially flat-topped response inside the band, with steep skirts at each end. Each filter output is then passed through limiter and clipper stages and is fed to a tuned audio discriminator whose output is linear with frequency. A cathode-coupled push-pull power output stage drives a string in the oscillograph for the actual photographic record. A block diagram of the ground station equipment is shown in Fig. 1. Auxiliary equipment in the ground station includes a large disc-recorder for simultaneous recording and interpolation oscillators for calibrating the audio discriminators.

Telemetering for Rockets

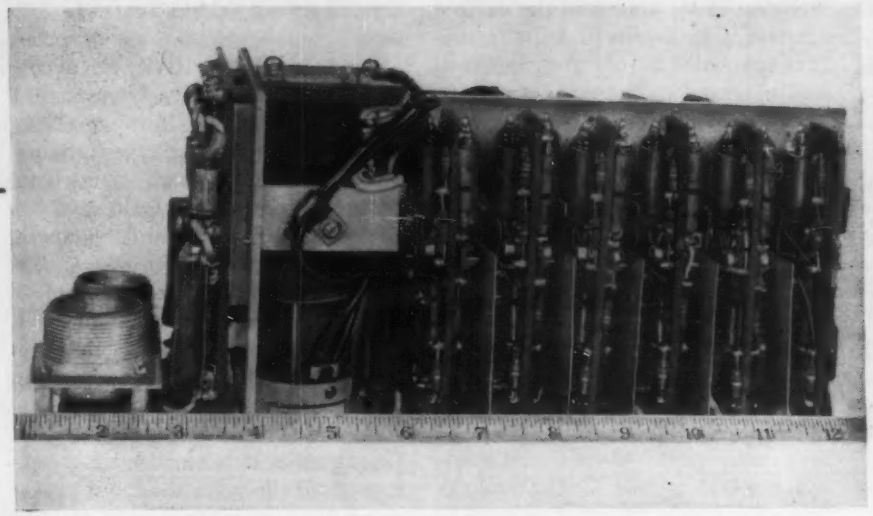


FIG. 2—Back view of audio case showing commutating switch and voltage-controlled oscillator. This unit weighs about 5 pounds

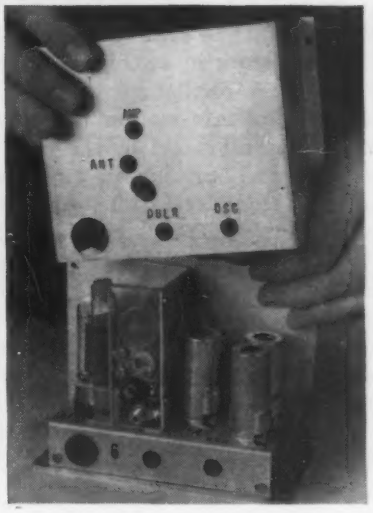


FIG 3—Front view of r-f portion of the telemetering transmitter

The Aerobee telemetering system, as supplied to the user group, is broken down into two parts: the audio case and the r-f transmitter. These units are mounted separately in the missile and are connected by a cable.

The audio case is of aluminum construction, occupies a volume of 281 cubic inches and has a maximum weight of five pounds. The use of commutation and switching of oscillators increases the amount of data which may be transmitted and a maximum of fourteen oscillators is provided for in the unit. A complete audio unit is shown in Fig. 2.

The transmitter is also of aluminum construction, has a volume of 60 cubic inches and weighs 1½ lb including cover and mounting plate. Figure 3 shows a front view of the transmitter. Excitation of the missile is employed to radiate the r-f signal and is accomplished by means of an insulated spike mounted in the nose. A slug-tuned loading coil couples the spike to the transmitter through a coax cable.

Power for telemetering is supplied from the missile power supply system, consisting of 28 volts of storage battery driving a bank of dynamotors, with three allotted to telemetering. These dynamotors furnish approximately 220 volts at 60 ma, although one may give as high as 400 volts to supply the transmitter final stage. Filament supply is taken from an 8-volt tap on the main battery and is adjusted to 6 volts by a resistor.

Audio Chassis

Three types of audio systems have been produced to date, with different electrical requirements for each one. Figure 4 shows the block diagram of the unit used in recent tests. Provision for the separation relay and commutating switch is included in all types and may be left out if not needed for the particular application at hand.

Two basic types of subcarrier oscillators are used: the TOL-1A inductance oscillator for pressure measurements, and the TOE-1A voltage-controlled oscillator for voltage measurements, including cosmic pulses. These units are dimensioned in a multiple system of

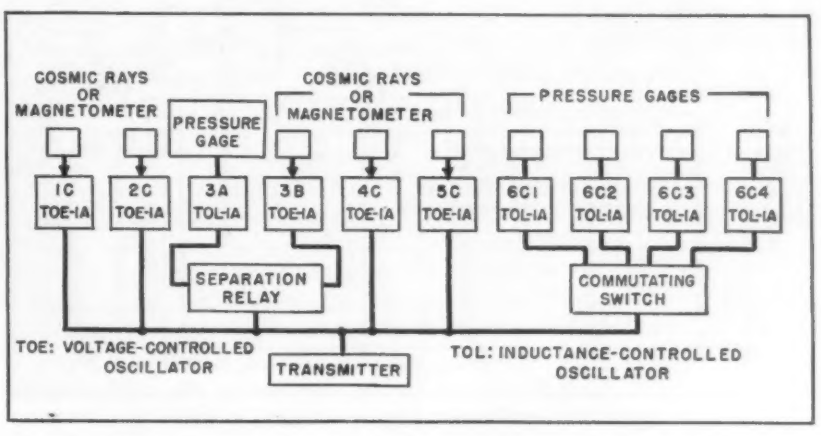


FIG. 4—Block diagram of audio case used in recent Aerobee flights

lengths, the TOE-1A being twice as long as the TOL-1A. Since both oscillators are the same width, two TOL-1A oscillators occupy the same space as one TOE-1A and these units may be interchanged in this fashion. A total of 10 TOE-1A oscillators may be used or 8 type TOL-1A oscillators in combination with 6 TOE-1A oscillators to give 14 channels of information. The vertical mounting panel in the case is drilled and tapped in universal fashion in order to take a variety of the two oscillators. Replacement or addition of oscillators on either side of the panel is readily accomplished in a short time.

The inductance-oscillator circuit for pressure measurements utilizes a single tube, the subminiature type 6K4. The pressure gauge forms the inductance of the tank circuit of the oscillator, a change in pressure varying the spacing of a mu-metal pad with respect to the iron-core coil. The gauge is mounted remotely from the oscillator unit and the two are connected together by a three-wire cable. Band selection is accomplished by tuning to the desired frequency by means of mica capacitors connected across the gauge coil and mounted in the oscillator unit. Current drain for the oscillator is approximately 3 ma at 108 volts while filament drain is 150 ma at 6 volts. The circuit is shown in Fig. 5.

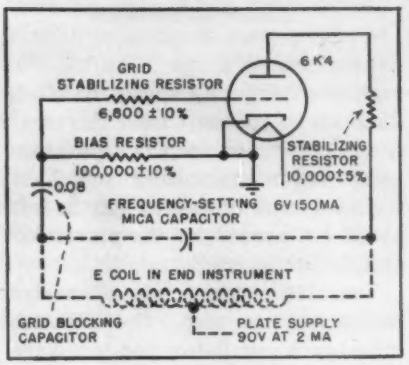


FIG. 5—Schematic diagram of sub-carrier oscillator with variable inductance end instrument

The TOE-1A voltage-controlled oscillator is a four-section phase-shift oscillator using three tubes. The resistance of one leg of the phase-shift network is supplied by a modulator tube, which has its plate resistance varied by the voltage under measurement applied to the modulator grid. A miniature triode, the 6C4, is used for the modulator; a subminiature 828A pentode is used for the oscillator stage, and a 6K4 functions as a cathode follower.

Since the cosmic-ray instrumentation output is in the form of negative pulses, the TOE-1A oscillator operates over the range from zero to −10 volts. With zero input to the modulator, the oscillator frequency is at the top end of the band. For the −10 volt condition, the frequency shifts downward to the low end of the band, giving a total change of 15 percent in frequency. Pulsing of the oscillator is straightforward and has given very good results.

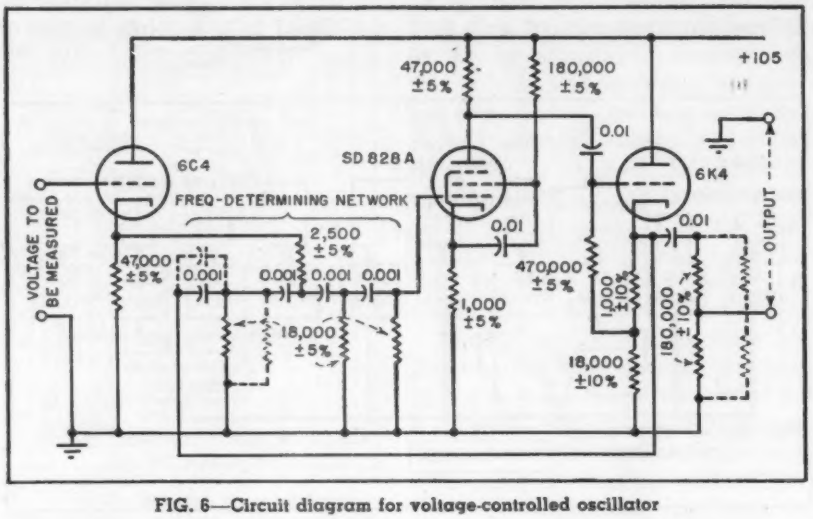


FIG. 6—Circuit diagram for voltage-controlled oscillator

In addition to the cosmic-ray pulse service, the TOE-1A has also been used to telemeter the operation of the emergency fuel cut-off receiver in the missile by measuring the limiter-grid voltage and the output thyratron grid and cathode voltages.

Modulation sensitivity is a constant percentage function for all bands, the zero to −10 range giving full bandwidth in each case. Sensitivity in cycles per volt varies from 35 cycles per volt on band 1 to 200 cycles per volt on band 6. The circuit diagram is given in Fig. 6. B+ current drain for the oscillator is 3.5 to 4 ma at 108 volts and A+ drain is 450 ma at 6 volts. Band selection is carried out by installing four mica capacitors in the phase-shift network and tuning to exact frequency with a small mica capacitor in parallel with the input capacitor of the network.

Two separate regulated B voltage supplies, with OB-2 miniature regulator tubes, are used in the audio case. These tubes are fed from separate dynamotors whose output voltage may vary over a wide range, due to load conditions or drop in primary battery voltage. All oscillators operate at a common value of 108 volts and may be interchanged from one supply to the other, with no change in calibration, and with good stability.

Provision for extra data beyond the normal six channels is accomplished in two ways: commutation, and channel switching by means of a relay. For commutation, a motor-driven cam-type switch using a maximum of four Acro snap-action switches is used to switch outputs of the oscillators at a rate of approximately four samples per second. A long cam-section gives an identifying mark for the record.

The relay switching system serves to substitute oscillators during flight and is applied in regard to booster action. Booster pressure is measured until separation, at which time the relay coil, normally energized, is de-energized by a pull-out plug on the booster. The booster pressure oscillators are turned off while another set is turned on. By

grouping outputs and switching with the 3-pole, double-throw relay normally used, any desired oscillator-time sequence may be obtained.

Output voltages from all oscillators are fed to a terminal board where each voltage is adjusted to proper level by means of individual voltage dividers. Provision is made for commutating at the same board as well as grouping of outputs for the separation relay.

Connections to the audio case are accommodated by three plugs mounted on one end of the case. The largest, a 19-pin AN connector, connects all end instruments to their oscillators. The second plug, a 10-pin AN connector, supplies all power and control circuits, while the third, a 5-pin connector, connects the r-f transmitter to the case and furnishes power and audio input to the transmitter.

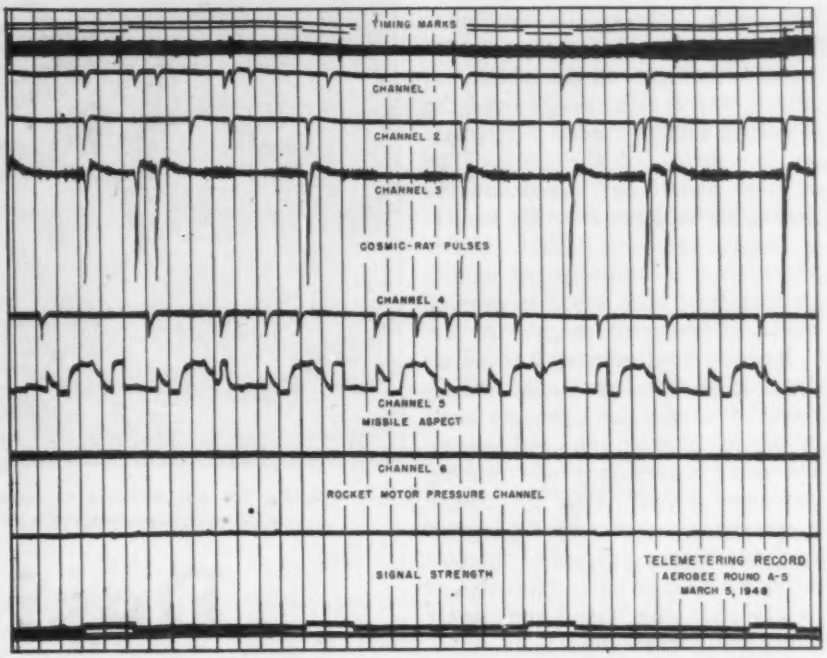


FIG. 7—Telemetering record from recent firing at Almagordo. Missile near peak of trajectory

The Transmitter

The f-m transmitter (Fig. 3) is a multistage unit with a reactance-modulated oscillator, a frequency-doubler stage, and a 2E26 tetrode final amplifier. Miniature tubes are used in the low-power stages, and are readily replaced in case of failure.

The low-power stages are supplied with 200 volts with a current drain of approximately 40 ma, while the B voltage for the final amplifier may be 250 to 400 volts supplied from a separate dynamotor. Current drain varies between 50 and 85 ma between the above limits. Total filament drain is 1.4 amp at 6 volts.

Deviation of the transmitter is set at ± 65 kc for 1 volt rms input to the reactance tube grid and harmonic distortion is less than 2 percent for this condition.

Tuning is accomplished by means of silver-plated slugs in all coils except the final amplifier, eliminating the need for variable capacitors. Tuning of the transmitter is conventional and straightforward. A low impedance link and coax cable couple the output to the missile nose-spike.

To facilitate rapid production of complete systems for future use, emphasis was placed on simplicity of design. The units are produced in two definite phases. In the first, the units are assembled in large numbers and held in stock for future use. Separate calibration curves are supplied with each audio unit and they are used in the final phase, the calibration of the basic units.

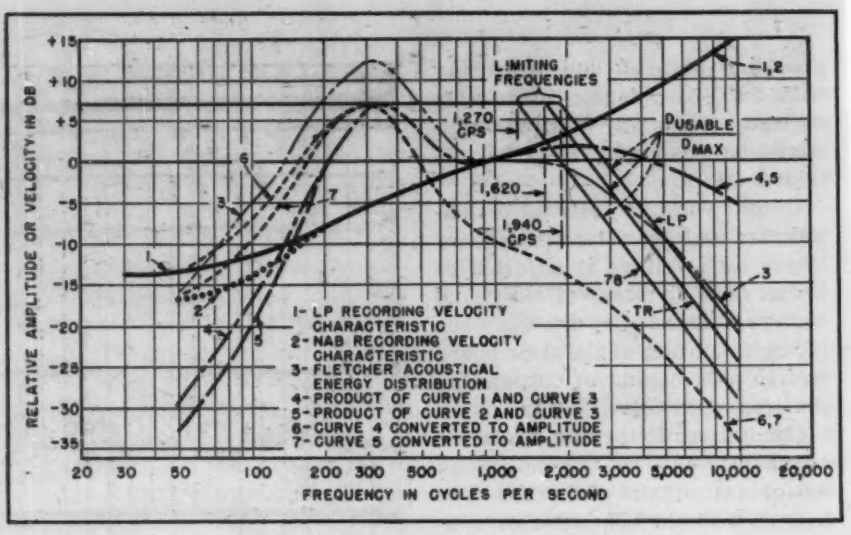
Results of Firings

The first round, fired in November, 1947, reached an altitude of approximately 200,000 feet. It was found necessary to cut off the rocket motor during flight since the missile drifted out of the prescribed trajectory limits. An emergency cut-off receiver in the missile, triggered from the ground, was telemetered and the record proved of value in determining the point of cutoff, as well as operation of the receiver during the critical part of flight.

The second round, fired March 5, 1948, proved even more successful. This missile attained an altitude of 78 miles and a wealth of useful cosmic-ray data was obtained from the telemetering records. Four channels of intelligence were devoted to cosmic rays, one to missile aspect, and the sixth was commutated to telemeter four rocket motor pressure functions. All channels functioned without failure and signal strength from the missile held up well during the flight despite the fact that the r-f transmitter had low voltage applied to the final amplifier stage and was giving less than 5 watts output. A portion of the record of this flight, recorded at Almagordo station some 43 miles from the firing tower, is shown in Fig. 7.

The third round, fired in April, 1948, was designed to measure the magnetic field of the earth and reached the same altitude as round number 2. Data channels were similar to those in round number 2, with magnetometer output voltages substituted for cosmic-rays. Telemetering was successful for some 326 seconds of flight.

The telemetering unit described in this article was designed by the writer using the basic Applied Physics Laboratory subminiature f-m/f-m system developed by the Telemetering Group at The Johns Hopkins University. At present, the production of the Aerobee telemetering equipment is being done by the Pacific Division of Bendix Aviation Corporation.



To evaluate the various types of records, their inherent properties are compared to the frequency-amplitude spectrum they have to accommodate

Design of L-P RECORDS

THE EARLY orthoacoustic phonographs depended on the driving power of the turntable motor to produce the sound. The motor turned the record, the groove of which vibrated the needle, and the needle in turn drove the diaphragm in the throat of the horn. The grooves had to be rugged and the pickup stylus large in order to produce a loud acoustic output. Under these conditions the record had to be turned at high speed to provide sufficient frequency range.

Because the industry has developed high-gain electronic amplifiers, dynamic loudspeakers and sensitive phonograph pickups to the point where they are reliable consumer goods, it is no longer necessary to use a record designed to produce sound directly. Groove deviation need be only great enough to maintain the signal sufficiently above the surface noise; the stylus tip need only be large enough to provide tracking for low-compliance low-inertia electrical pickup cartridges. The analyses of these considerations, on which the long-playing record (ELECTRONICS, p 86, Sept. 1948) was designed, were presented in a paper by Peter C. Goldmark and René Snepvangers of Columbia Broadcasting System and William S. Bachman of Columbia Records before the New York Section of the IRE in September. Here is a discussion of the highlights of the paper; it will be published in its entirety in the *Proc. IRE*.

Design Factors Evaluated

The public's familiarity with phonograph records makes it desirable to solve the problem of providing uninterrupted music reproduction by using records as the basic medium. A study of the playing time for classical compositions shows the average to be about 40 minutes. Thus, if a record were to accommodate 20 minutes of playing time on a side, it would accommodate most compositions. One record would then replace an album of several and therefore save the consumer money and storage space, as well as 90 percent in total weight. For these reasons, the possibility of producing a long-playing record seemed desirable.

From geometric considerations, the maximum playing time was found to be obtained if the inside recording diameter was half the outside diameter. To use a smaller inside diameter would require a higher rate of revolution (to maintain the same minimum linear velocity at the innermost groove), thus decreasing the playing time. A larger inside diameter, reducing the number of grooves, would decrease the playing time more than the permissible decrease in record speed would increase it.

With a 12-inch record, the outside recording diameter of which is 11.5 inches, the inside diameter would thus be 5.5 inches. Although at this point the design of the record might be achieved by finding the linear velocity and the tip radius of the stylus necessary to reproduce the required high frequency, it is simpler to arbitrarily decide on a turntable speed (linear velocity). As low a speed as possible is desirable, but too low a speed would create serious problems of rumble. Because so much experience has been gained with transcription equipment operating at 33⅓ rpm, this speed was chosen. At this speed, 230 grooves per inch are necessary to provide 20 minutes of playing time; the nearest practical value is 224 grooves per inch. The peak groove displacement for 224 grooves per inch is thus 0.0009 inch and the linear velocity of the innermost groove is about 9.6 inches per second.

The wide frequency response of frequency-modulated broadcasting and of professional wire recorders suggests that improvements in the frequency range of records are also in order. To meet this requirement, a frequency range from 30 to above 10,000 cps is desirable.

Relative Performance

By way of evaluating the long-playing record having these characteristics, its performance was compared to that of conventional 78-rpm records and transcriptions. To establish an analytical basis for comparison, the condition where the radius of the reproducing stylus and the minimum radius of curvature of the recorded wave are equal was arbitrarily chosen as the limiting condition, and the corre-

A needle tip of one-mil radius, a tracking weight of about 6 grams and 224 grooves per inch characterize pressings that can contain from 30 to above 10,000 cps

Choice of groove width and spacing of long-playing records is based on considerations of playing time of classical compositions, minimum linear velocity, tracking, maximum deviation, and cost

sponding frequency termed the limiting frequency. This condition is reached when $f_L = V/2\pi(R_{EFF}D)^{1/2}$ where f_L is the limiting frequency, V is the linear velocity, R_{EFF} is the effective radius of the reproducing stylus, and D is the groove deviation. This equation shows that, if the deviation is very small, the limiting frequency can be very high.

The limiting frequencies for the three types of records are tabulated on the accompanying diagram. If the frequency is greater than the limiting value, the deviation for equal radius of needle tip and groove modulation must be made less than maximum. This consideration establishes a usable deviation as a function of frequency.

The percent usable deviation for the inside groove of the three types of records is also shown in the diagram as a function of frequency. Full deviation is 0.002 inch for 78-rpm records, 0.0011 inch for transcriptions and 0.0009 inch for L-P records; inside groove diameters are respectively 4, 8 and 9.6 inches.

Another way to evaluate the records is on the basis of the harmonic distortion produced in tracing the grooves. Because of the symmetry of this tracing error, there will be no second harmonic distortion. However, there will be third harmonic distortion. In this way it is found that, for the inside groove and at any given frequency, the relative tracing distortions at maximum deviation of the systems are $T_{78}/T_{LP} = 5.35$ and $T_{TR}/T_{LP} = 1.91$. Thus the tracing distortion of L-P records is about a fifth that of 78-rpm records and about half that of transcriptions. Were it not that the maximum displacement of the groove was rarely required at high frequencies (above the limiting frequency), the tracing distortion from all three recording systems would be excessive.

These inherent limitations of the recording systems, to be indicative of their practical abilities to accommodate actual program material, need to be evaluated in terms of the amplitude-frequency content of the recorded material. The diagram shows the most probable energy distribution curve for a 75-piece orchestra as determined by Fletcher. The recording characteristic of the L-P record is also shown, together with the NAB recording characteristic for comparison. (The L-P characteristic has a slight bass lift to reduce rumble and hum level.) The most probable recording velocity distributions can be obtained by adding ordinates (in db) of the two curves. The resultant curve shows that the most probable amplitudes lie below the maximum limits determined by the limiting frequency and usable deviation for all three types of recording. However, L-P records lie further from the required curve than the others and can be expected to have less distortion.

Phonograph Pickups

As indicated earlier, the possibility of using the L-P recording system depends on technological development of pickups that require very low driving force at their styli and have high sensitivity. The use of Vinylite as the record base reduces the surface noise so that even with the small recorded groove deviations the signal-noise ratio is acceptable. The use of lightweight pickups further improves this ratio so that a dynamic range of 45 db with an acceptable background noise level is obtained.

The development of suitable pickups was a part of the overall program. The needle radius should be 0.001 inch plus or minus 10 percent. A downward tracking force not exceeding 6 grams is desirable. The theoretical compliance, measured at the point of the stylus, for low-frequency tracking of 78-rpm records with this low tracking force is 0.87×10^{-6} cm per dyne and, for L-P records, it is 0.39×10^{-6} cm per dyne.

Crystal cartridges producing about 0.5 volt rms at reference frequency and level can be built within these limitations. It was also found that r-f modulation pickups (like Cobra) and variable-reluctance type pickups (like GE) are also suitable for design as L-P pickups. The rapidity with which suitable pickups have been developed commercially verifies the basic assumption that the art has progressed to the point that this new approach to recording is justified.—F.H.R.

HUM REDUCTION

Intensive investigation of problem results in useful circuit design data for minimizing hum from alternating magnetic fields, electrical leakage, input circuit wiring and heater-cathode leakage current

By ARTHUR F. DICKERSON

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SOURCES of hum fall into two broad classifications: hum arising from causes external to the tube which act either upon the tube or upon the components of the circuit, and hum arising within the tube as a result of its characteristics. The first classification covers hum from alternating magnetic and electrostatic fields and from leakage and stray capacitances in the circuit wiring, while the second includes heater-to-cathode leakage and the action of the heater field within the tube.

The most common sources of alternating magnetic fields are transformers and chokes. There are also fields surrounding the wires carrying the heater current and the a-c primary supply, but these fields are extremely small by comparison. The intensity of the field in air at a distance of one inch from a single wire carrying one ampere is in the order of 0.08 gauss, while the stray flux from transformers may be more than a hundred times greater than this value.

The amount of stray flux for a specific transformer is determined by the design of the core and is practically constant over the normal load range. It is difficult to assign a general value to the magnitude of stray flux since it is dependent largely upon the quality of the transformer. However, the order of magnitude for average-quality transformers is 5 to 10 gauss at a distance of two inches from the core in the active portion of the flux pattern.

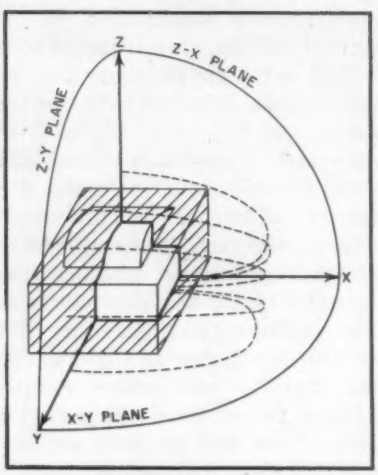

FIG. 1—Stray flux pattern for transformer with E-type core laminations

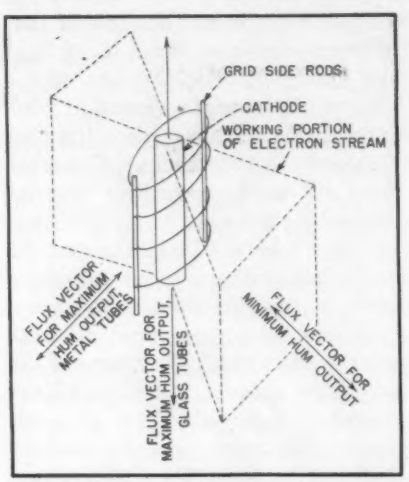
GRID SIDE RODS
CATHODE
WORKING PORTION OF ELECTRON STREAM
FLUX VECTOR FOR MAXIMUM HUM OUTPUT, METAL TUBES
FLUX VECTOR FOR MAXIMUM HUM OUTPUT, GLASS TUBES
FLUX VECTOR FOR MINIMUM HUM OUTPUT

FIG. 2—Tube with concentric type construction

Figure 1 shows the flux pattern for a transformer with E-type core laminations. This pattern is quite similar to that of an air-core coil, except for modification due to the iron core of the transformer. The pattern is represented as if the transformer were suspended in air. The presence of a chassis of magnetic material will have little effect upon the portion of the field which is two inches or more above the chassis, but the field in the region of the chassis will be extended due to the lower reluctance path. Some advantage may be gained in this respect by the use of vertical-mounting transformers in preference to the half-shell types of construction.

The flux concentration point at which the major portion of the flux leaves and enters the core is located at the ends of the core segment on which the winding is made. This point is further from the chassis in the vertical-mounting transformers, thus reducing the extension of the field. The directional properties of the stray flux are also more favorable in transformers of the vertical-mounting type than in transformers of the half-shell type regardless of the material used in the chassis.

Hum In Receivers

An alternating magnetic field was applied to each tube of three different receivers, which ranged from communications types to commercial five-tube table models and

Common Sources of Hum and Their Solutions

Cause of Hum	Maximum Hum Level at Grid	Solutions
Modulation of plate current by stray flux from power transformer		Proper orientation of tube with respect to power transformer
Glass pentode	2.00 mv	Selection of proper size plate load resistance. (See text)
Glass triode	0.30 mv	
Metal pentode	0.10 mv	
Metal triode	0.02 mv	
Heater-to-grid leakage across socket	10 to 15 μv for each megohm of grid resistance and each volt rms of heater above ground	Use of double-ended tubes. Adjustable ground position on secondary of filament transformer
Leakage or induced voltages in closed loops of the input circuit	Up to 75 μv	Use of double-conductor input cable as shown in Fig. 5
Heater-cathode leakage	Currents of 0.04 to 1.0 microampere	Adequate bypassing of cathode for power frequency. Use of low cathode impedances

included both f-m and a-m reception. The antenna was disconnected and the gain control advanced all the way. The field intensity was then increased until the hum level became audible above the noise. This was repeated individually for each tube in the set.

It was found that in most cases a field of 50 gauss rms would produce audible hum when applied to the r-f amplifier, converter, i-f amplifiers, or the first audio stage. The power-output stage, and the detector or discriminator stage in circuits employing separate tubes for detector and first audio were not affected by fields as high as 150 gauss rms.

Since it has been shown that a representative figure for escape flux from a power transformer is 5 to 10 gauss, it would seem that the tube itself offers no particular problem as to hum. In many cases this may be true. However, the value of 5 to 10 gauss was given for a distance of two inches from the core of the transformer, and the field intensity increases inversely as the square of the distance from the transformer. The fields in the immediate vicinity of the transformer are therefore quite high, and placement of critical tubes in this region should be avoided.

In addition, the final measurements in the test outlined were made aurally, and the hum components, both 60 and 120 cycles, were less audible than the higher-frequency noise which was used as a reference. In the fields of audio work this is a legitimate criterion, but in measurement and control equipment the hum must be considered on the basis of its rms value.

A considerable amount of data has been taken on several different tube types under varying field intensities and circuit conditions. A few representative figures may be quoted for general guidance. An arbitrary unit (microvolts-per-gauss referred to the grid) has been selected since it takes into account the gain of the tube under test as well as the strength of the field, and in addition is more easily referred to the signal level at which the tube is expected to operate.

The hum level of the pentode-type amplifier does not increase linearly with an increase of field intensity, but varies at a rate somewhere between the first and second power of the field intensity, depending upon the reference level of the magnetic field. Thus, for glass-type pentodes, a hum level of about 250 microvolts-per-gauss (referred to the grid) may be expected at field intensities of around 45 gauss, while at 5 gauss the figure drops to around 20 microvolts-per-gauss. Values for comparable metal-type pentodes are in the order of 5 microvolts-per-gauss and increase only slightly between 5 and 45 gauss due to shielding effect of the metal envelope. Triode types show hum levels of around 30 microvolts-per-gauss at 45 gauss, and 7 microvolts-per-gauss at 5 gauss.

The orientation of the tube elements in a magnetic field determines largely the influence that the field will have upon the output of the tube. A tube of concentric-type construction is shown in a cutaway view in Fig. 2. A major portion of the electron stream can be considered bidirectional along a line which is perpendicular to the plane of the grid side rod supports at the cathode. The magnetic field will deflect the electron stream a maximum when the flux is perpendicular to the path of the electrons. These maximums occur when the flux vector is coaxial to the tube, or when perpendicular to the tube axis and in the plane of the grid side rods. As a general rule, metal tubes and glass tubes which have nonmagnetic side rods show a maximum in the direction normal to the tube axis, while those with magnetic side rods have a maximum in the axial direction, the difference between the two conditions being in the order of 6 to 10 decibels in voltage. Example:

	Axial Flux Hum Voltage at Plate of Tube	*Normal Flux Hum Voltage at Plate of Tube*
6SJ7GT	1.5	0.5
6SJ7	0.02	0.04

The minimum hum condition for all types occurs when the flux vector is perpendicular to the tube axis and normal to the plane of the grid side rods. The minimum is down 30 to 40 decibels from the maximum in glass types and 10 to 20 decibels in metal types, the difference arising from the distortion of the field in the metal type which prevents a sharp minimum.

Since the minimum occurs only

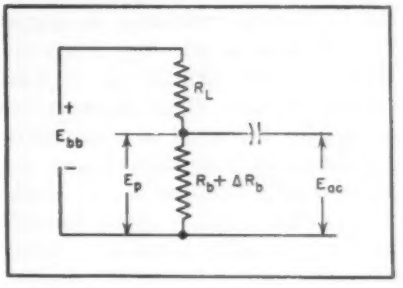

FIG. 3—Equivalent circuit for a tube operating in a magnetic field with no signal on the grid

when the flux is directed perpendicular to the tube axis, rotation of the tube socket is not effective in removing hum when the flux vector is parallel to the tube axis. It is possible to rate a transformer on the basis of the direction of stray flux vectors in the area adjacent to the transformer, normally occupied by tubes. In this respect the vertical-mounting transformer is superior to the half-shell type, since more of its flux is perpendicular to the usual tube mounting axis in the space occupied by the tube elements.

If a tube is operated in an alternating magnetic field, the hum output is a function of the strength of the field, the constants and voltages of the circuit, and the characteristics of the tube. Consider a tube operating in a magnetic field without a signal on the grid. The equivalent circuit is shown in Fig. 3. The effect of the field

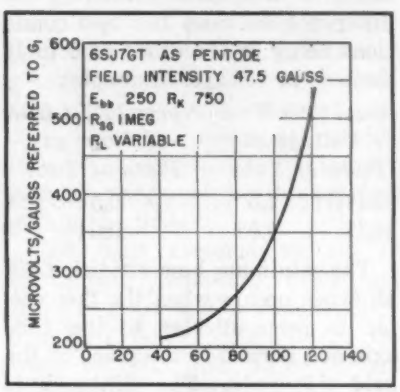

FIG. 4—Variation of hum with gain in a typical pentode amplifier

upon the tube may be considered as a change in the static plate resistance of the tube. The sign is shown as positive since only in comparatively rare tube designs is the static plate resistance decreased by application of the magnetic field. In this circuit: R_L = load resistance, R_b = static plate resistance, ΔR_b = change in static plate resistance at peak flux, E_{bb} = d-c plate supply voltage, E_b = static plate voltage, E_{ac} = peak-to-peak hum output voltage and I_b = static plate current.

Let the subscript 1 refer to normal operation (that is, operation in the absence of a magnetic field) and subscript 2 refer to operation at peak flux value. Then:

$$E_{ac} = (I_{b1} - I_{b2})R_L \quad (1)$$

$$I_{b1} = \frac{E_{bb}}{R_L + R_b} \quad (2)$$

$$I_{b2} = \frac{E_{bb}}{R_L + R_b + \Delta R_b} \quad (3)$$

Substituting Eq. 2 and 3 in Eq. 1

$$E_{ac} = \left(\frac{E_{bb}}{R_L+R_b} - \frac{E_{bb}}{R_L+R_b+\Delta R_b}\right)R_L \quad (4)$$

$$= \frac{E_{bb}\,R_L\Delta R_b}{(R_L + R_b)\,(R_L + R_b + \Delta R_b)} \quad (5)$$

$$E_{b1} = \frac{E_{bb}\,R_b}{R_b + R_L} \quad (6)$$

$$\Delta R_b = KR_b \quad (7)$$

where K is a function of static plate voltage and flux density.

Substituting Eq. 6 and 7 in Eq. 5

$$E_{ac} = \frac{KE_{b1}\,R_L}{R_b + R_L + KR_b} \quad (8)$$

$$K\,R_b << (R_b + R_L) \quad (9)$$

Eq. 8 may be written

$$E_{ac} = K\,\frac{(E_{b1}\,R_L)}{(R_b + R_L)} \quad (10)$$

Experiment has indicated that K is a function of $1/E_b$ within the normal limits of E_b encountered in a resistance-coupled amplifier. If the peak value of flux remains constant, for a specific tube:

$$KE_b = \text{a constant} \quad (11)$$

Then

$$E_{ac} = \frac{R_L}{(R_L + R_b)} \times \text{a constant} \quad (12)$$

If the tube is a triode, the static plate resistance R_b is fairly constant for different values of R_L, and in addition R_L is usually much larger than R_b. Equation 12 indicates that if this is the case, E_{ac} is reasonably independent of the circuit values.

In the case of a pentode, R_b decreases with an increase of R_L and since R_b and R_L are of the same order of magnitude:

E_{ac} is a function of

$$\frac{R_L}{(R_L + R_b)} \times \text{a constant} \quad (13)$$

It will be noted that this expression for hum output voltage is quite similar to the familiar formula for output signal voltage:

$$E_o = \frac{\mu E_g\,R_L}{R_L + R_p} \quad (14)$$

in which case μE_g represents the constant. The major difference is that R_b in the hum formula is static plate resistance, E_b/I_b, while R_p in the signal-voltage formula is dynamic plate resistance.

It has been shown that in the usual application for triodes ($R_L \gg R_b$ or R_p) the output hum level is relatively independent of the plate load resistance, as is also the gain. Hence, for triodes, the hum level referred to the grid is constant for a given value of flux.

In pentodes, R_b varies inversely with R_L, and R_b remains practically constant over the flat portion of the plate characteristics. Thus, if R_L is increased, assuming R_L and R_p of like magnitude, the gain in-

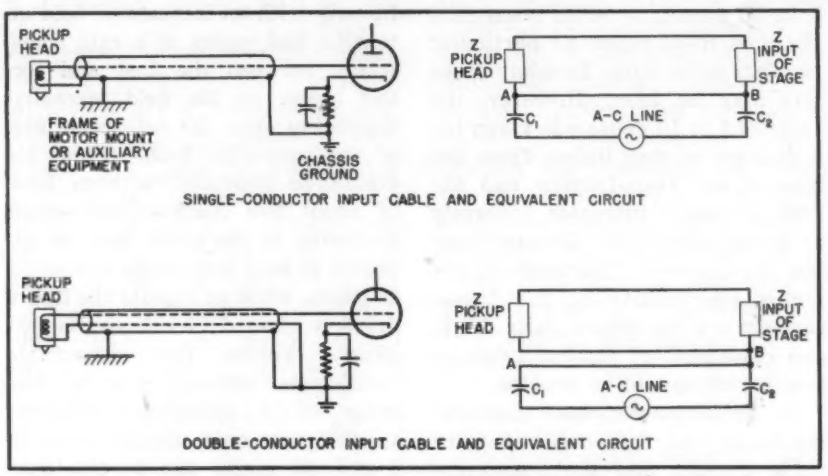

FIG. 5—Actual and equivalent input circuits for single and double-conductor shielded input cable. Reduced hum is achieved with double-conductor cable

creases by an amount less than the increase in R_L, but the hum output increases directly as R_L. The hum level referred to the grid of a pentode increases, therefore, with an increase of the plate load resistance as demonstrated in Fig. 4.

The output from metal types was approximately 40 decibels down in voltage from that of glass types. The placement of a close-fitting iron shield over the glass tube reduces its hum to within 2 or 3 decibels of the metal type.

The wave form of hum output for the metal type is for the most part fundamental, with a small amount of second harmonic, while for the glass type it is second harmonic with varying amounts of higher-order even harmonics. This represents an advantage for the metal type when viewed from an audibilty standpoint, since a 120-cycle note is much more readily heard than a 60-cycle note. A 60-cycle note, to sound as loud as a 120-cycle note, must be about 3 decibels greater in power.

Electrical Leakage

The leakage impedance between socket pins contributes hum to stages with a-c heaters to a degree dependent upon grid-circuit impedance, pin placement, socket material and heater-to-grid capacitance. Consider a voltage divider made up of the leakage impedance from heater to grid pin ($Z_{leakage}$) and the impedance from the grid to ground (Z_{grid}). The voltage which appears across this divider is determined by the wiring of the heaters, and the portion of this voltage which appears at the grid is determined by the ratio of grid-circuit impedance to leakage impedance. Since normal Z_{grid} is much smaller than $Z_{leakage}$, the voltage at the grid is almost directly a function of the grid-circuit impedance and inversely a function of the leakage impedance.

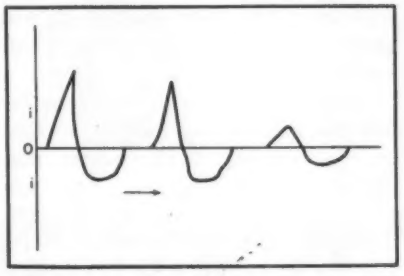

FIG. 6—Typical waveforms of heater-cathode current

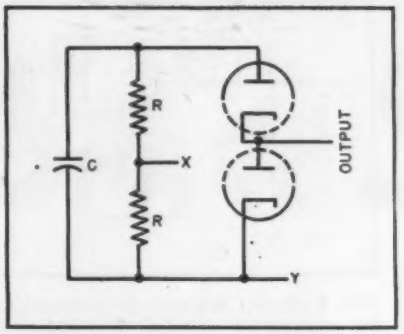

FIG. 7—Basic ratio-detector circuit

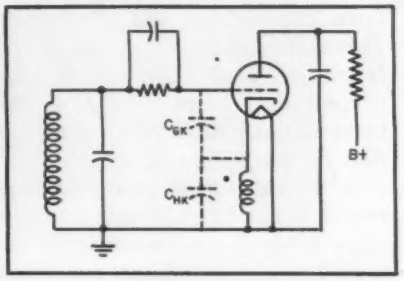

FIG. 8—Variations of C_{HK} may cause hum through frequency modulation of local oscillator

Isolantite-type sockets have the highest leakage impedance, which is almost entirely capacitive reactance. Next best are polystyrene, mica-filled Bakelite and black Bakelite, in that order, with varying amounts of resistive components. Since the leakage impedance is predominantly capacitive even in the worst sockets, the elimination of harmonics in the heater supply is of great importance. The leakage impedance decreases for the higher-order harmonics. In addition, the gain of the stage is usually greater. Thus a sine-wave heater voltage appears as a sine-wave output at the plate, but a complex wave at the heater is reproduced with greater harmonic content at the plate. Representative values of hum to be expected from this source are 10 to 15 microvolts at the grid for each volt of heater potential above ground with a 1-megohm grid impedance.

When one pin of the heater is grounded there is a single source of leakage voltage, which arrives at the grid leading the heater voltage by 90 degrees. When the heater is above ground in a series string, the leakage from both pins arrives in-phase at the grid. However, if the heater is operated from the secondary of a power transformer with the center-tap grounded, the leakage from the two pins arrives at the grid out-of-phase, but with different magnitudes. This partial bucking effect may be utilized completely by grounding the heaters through the center tap of a potentiometer with the outside arms connected to the heater supply, and then adjusting the ground tap for cancellation of the two leakage voltages.

Double-ended tubes such as the 6J7 offer a distinct advantage in the problems of hum from leakage since their grid connections are well removed from the heaters. As an example, the 6J7 has one-tenth the hum of the 6SJ7 in this respect.

Input-Circuit Wiring

Careful attention to the wiring of input circuits will frequently reduce the hum of low-level amplifiers. Figure 5 shows the equivalent circuits for single and double-conductor shielded input cable. Units C_1 and C_2 are leakage capacitances to the a-c line in the amplifier and in the auxiliary equipment. For the single-conductor cable a closed circuit is made which has a portion of the grid-return lead in the loop. This closed circuit may act either as an electrical-leakage path or as a magnetic loop, depending largely upon the line connections and the size of the leakage capacitances.

The resistivity of ordinary shield braid over a single conductor is roughly 0.003 ohm per foot. Capacitors C_1 and C_2 then must be rather large to produce an appreciable voltage drop along the shield. However, in the case of a grounded line, C_2 becomes a direct connection and C_1 may be as high as 0.1 microfarad due to the line-isolation capacitors in certain types of equipment. With a grounded 115-volt line, 0.1-microfarad leakage will produce 50 microvolts across three feet of shield.

Frequently the leakage path of

C_1 and C_2 is shorted out by a ground strap between the two chassis or some other direct connection. In this case the closed circuit acts as a magnetic loop subject to the stray flux of the equipment. Hum levels as high as 75 microvolts at the grid have been encountered in tests from this source.

The use of two-conductor shielded cable as shown isolates the input circuit from any closed loop which the shield may make with auxiliary equipment, and thereby prevents a voltage drop which may appear along the shield from being reflected through the pickup impedance to the grid. This principle can also be appplied to the use of ground straps.

The careful elimination of all closed loops in the grounding connections will frequently reduce the hum level of the equipment. Ground connections inside the chassis follow the same pattern, so that the cathode-grounding point and the ground end of the grid circuit should always be connected at the same point on the chassis and should be independent of other circuits, except at the chassis point.

Sources Within the Tube

The heater is the only tube element intentionally carrying alternating current at the power frequency. The heater for indirectly-heated-cathode types is coated with a ceramic-like material to insulate it from the cathode sleeve which encloses it. Of several possible ways for alternating current exciting the heater to act upon the other elements and cause hum, the most important and probably the only one that causes noticeable hum in receiving tubes is leakage current between heater and cathode. Modulation of the plate current by the alternating field of the heater is negligible in modern receiving tubes.

Extensive work is being done to establish the nature of heater-cathode leakage current but the information is not yet complete. It may be stated that the current is due mainly to a combination of three phenomena: capacitive coupling between heater and cathode, direct (more or less resistive) leakage between them and emission

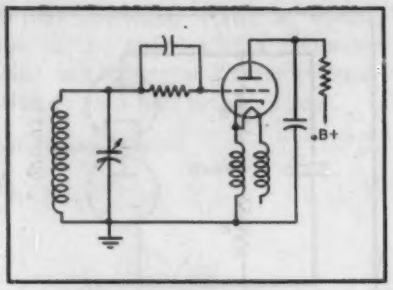

FIG. 9—Heater and cathode arranged to be at same r-f potential, thus reducing hum due to variations of C_{HK}

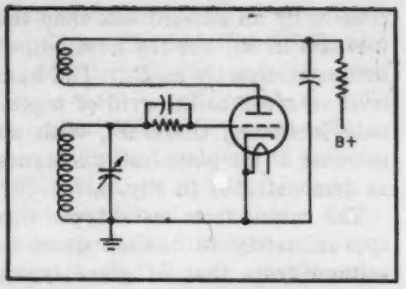

FIG. 10—Tuned-grid tuned-plate oscillator with grounded cathode to minimize effect of variations in C_K

from the cathode and the heater. Three frequently occurring waveforms of heater-cathode leakage current are shown in Fig. 6 and these indicate that this current is rich in harmonic content.

If the cathode is grounded, current will not affect operation. The same holds for an adequately bypassed-cathode-resistance condition. However, there are numerous cases such as cathode followers, phase inverters, and detectors where the heater-cathode leakage current will cause a voltage drop across the cathode resistance if the heater is returned to ground. To present satisfactory design data it is necessary to consider this current.

The heater-cathode impedance is so large when compared with the normally used cathode resistance that the current source may be considered as a constant-current generator. In tubes which are manufactured with an aim to minimizing heater-cathode leakage, current of 0.04 microampere is common where the heater voltage is 6.3 volts rms and where the cathode is returned to one end of the heater through a resistance. In some types such as output tubes, where hum requirements are less severe, this current may be as high as 1.0 microampere. Fortunately the degenerative action of an unbypassed cathode resistance tends to lessen the effect of the leakage current.

A frequently used circuit in f-m sets is the ratio detector. The schematic circuit is given in Fig. 7. The ground is connected either at point X or at point Y. The former is called a balanced ratio detector. The hum due to heater-cathode leakage current is 3 or 4 times greater with a balanced circuit than with the unbalanced circuit obtained when point Y is grounded. The hum increases, of course, with increased resistance values. Also, the larger the resistances, the greater the difference between the balanced and the unbalanced circuit. This is due to the loading effect of the diodes.

The increased use of the higher-frequency television and f-m bands has presented an unusual problem of hum arising in the local oscillator. Figure 8 shows a circuit diagram of a typical high-frequency local oscillator. The a-c heater supply causes the heater-to-cathode capacitance, C_{HK}, to vary at the power frequency. This arises from either thermal variations of the heater insulation or from mechanical vibration of the heater, possibly from a combination of the two.

Since the heater-to-cathode capacitance appears in series with the grid-to-cathode capacitance, C_{GK}, across a portion of the grid tank, any repeating variation of C_{HK} will cause the oscillator frequency to vary. At the higher frequencies the capacitance in the grid tank is extremely small so that a small change of C_{HK} will vary the oscillator frequency enough to produce an f-m signal in the i-f strip. It has been estimated that a heater-cathode capacitance change of one part in two million in television channel 13 will produce audible hum at the loudspeaker.

Figures 9 and 10 show two methods for minimizing hum from this source. In Fig. 9 the heater and cathode of the oscillator tube are operated at the same r-f potential. This method has proved satisfactory up to 200 mc. The tuned-grid tuned-plate circuit of Fig. 10 enables the cathode to be operated at ground potential.

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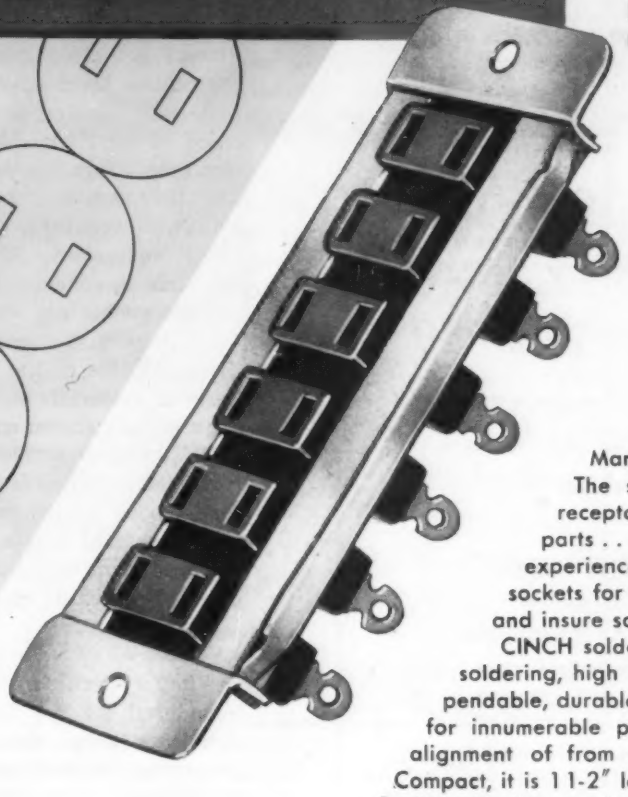

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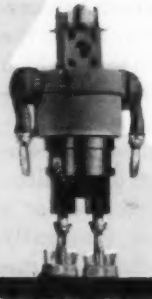

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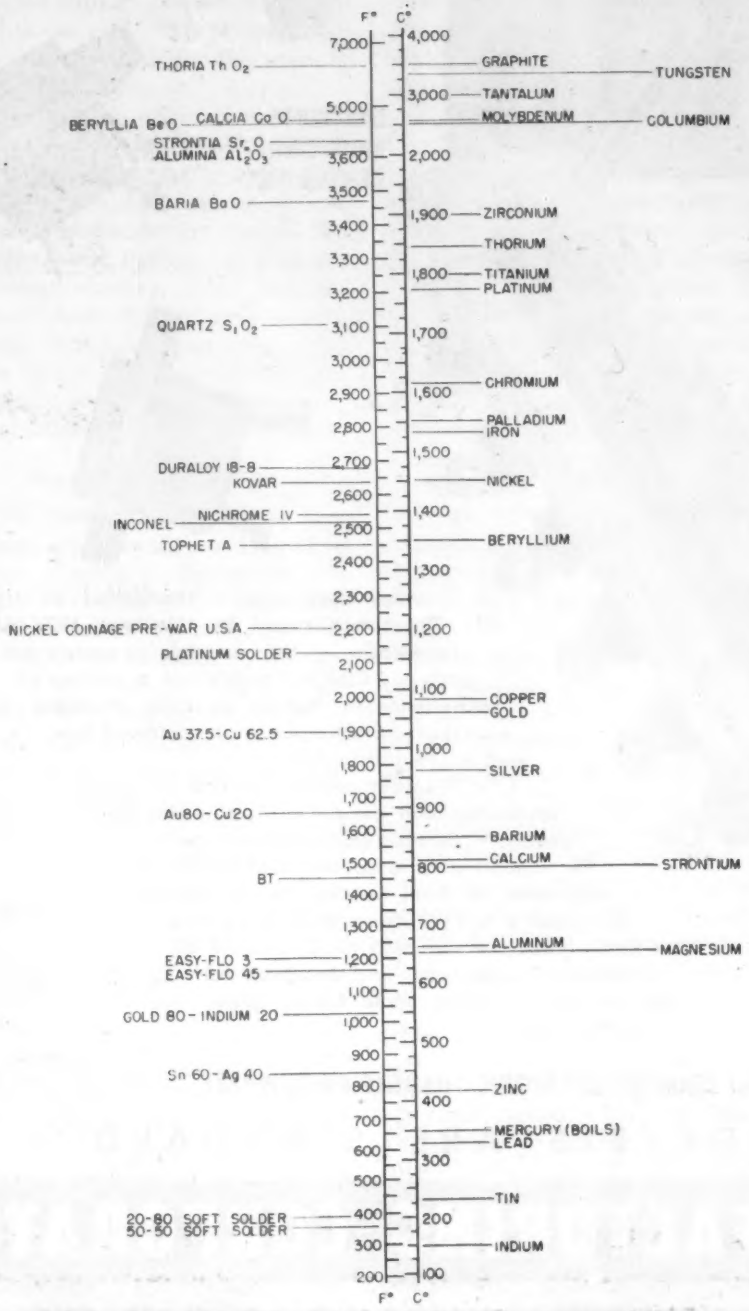
Melting-Point Chart

Metals, alloys and ceramics commonly used in electron tubes are covered. Critical temperatures are given in degrees Fahrenheit and centigrade

By K. H. McPHEE *Research Division, Vacuum Tube Laboratory*
Collins Radio Company, Cedar Rapids, Iowa



THE MELTING POINT CHART is a thermometer-type graph upon which are placed the melting points of metals, alloys and ceramics most commonly used in electron tubes.

A linear scale representing degrees F is located on the left side of the central thermometer. A linear scale representing degrees C is located on the right side of the thermometer. Any line drawn through the thermometer, normal to its length, designates a C reading and the F equivalent. Above 2,000 C, the scale is condensed.

Pure metals are shown opposite their respective melting points on the right side of the thermometer. Ceramic materials and metal alloys are similarly shown on the left.

The melting temperature shown for ceramic bodies is that temperature above which no crystalline phase normally exists. No attempt has been made to indicate their progressive softening characteristic.

Uses

When a specific material is being considered for use because of desirable electrical, chemical or other properties, the melting point is easily obtained. Conversely, where the temperature range within which materials must work is known suitable ones can be quickly selected.

Fabrication techniques may employ soldering, brazing, or welding, and the most suitable method for a particular material is frequently determined from the chart. Similarly, where sequential heating operations are planned it is useful.

The chart also facilitates rapid conversion between F and C scales.

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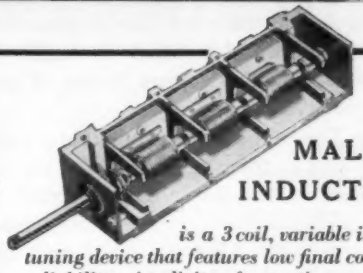

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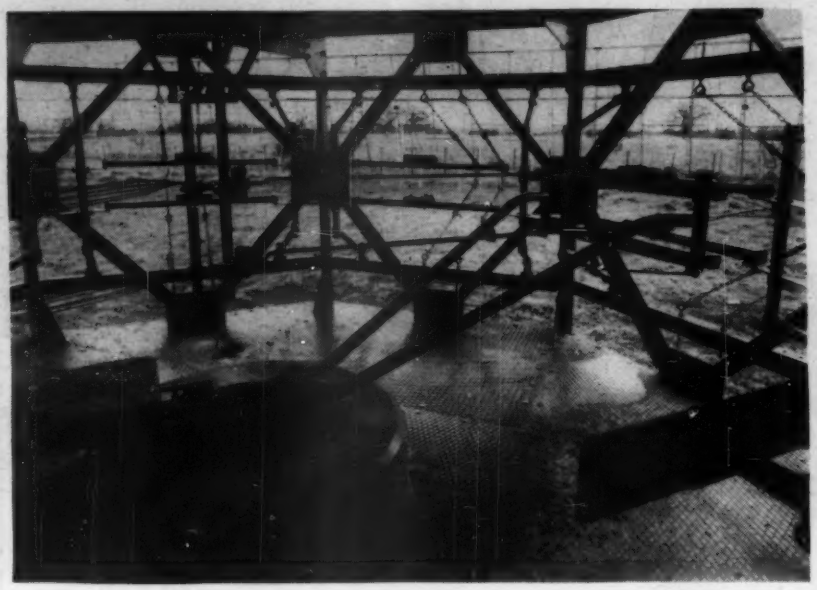


Inside base of an antenna switching tower showing one of six stacked switching arms. The remotely controlled motor is mounted in the large box in the center

British Valves at Work

McGraw-Hill World News

WITH a frequency accuracy of one part in a million and occasional effective radiated power output of 1,500 kw from six transmitters, the BBC transmitting station at Skelton, England, incorporates many ingenious and effective methods for band and antenna switching. The station operates on the short-wave bands and it was constructed specifically for the purpose of transmitting to European countries, Latin America and certain parts of the Pacific.

These transmissions are radiated in some thirty-six languages, and the service continues through day and night, changing frequencies and directions as demanded by conditions of propagation and location of areas to be served. The station was built during the war and designed to ensure reliable transmissions despite enemy jamming efforts.

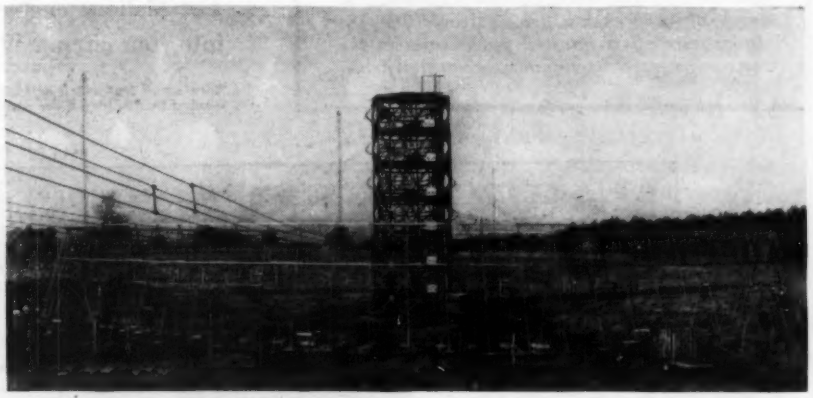
In all, there are 51 antenna arrays strung between 31 masts ranging in height from 200 to 350 feet. The remote antenna switching system is perhaps the most interesting feature of the station. Any one of the six transmitters may be connected between a certain number of arrays, thus enabling the output of a transmitter to be beamed to any part of the world.

A picture of one of the giant multipole switches is shown. These towers are forty feet high and built in six levels, each being connected to a certain transmitter. The switching arm is controlled by an electric motor. The antenna arrays are in the form of stacked horizontal arrays.

The master oscillators are not crystal controlled, but excellent stability is possible through the use of double temperature control where the temperature inside the frequency determining unit is controlled and the temperature of the room housing the unit is also constant. The oscillators operate at comparatively low frequencies and the frequency is multiplied in harmonic generators with a switching arrangement for optimum flexibility.

Another ingenious design feature is the mounting of tuned circuits on trucks. These units are wheeled into the rear of the transmitter cabinet, and contact is made by spring-loaded copper blades of generous area.

The audio driver delivers 1,200 watts to the class B modulators and each of the latter can dissipate up to 75 kilowatts on its anode. Each tube takes 2.5 amperes of grid current on drive peaks. The modulation transformer carries up to 20



One of the forty-foot rotary switches used in the BBC's Skelton station for antenna switching. Each of the six decks contains a switch

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The number of torches used can be varied at will. Three are shown in use, cutting out large washers, while four are in operation on the front-cover setup for cutting paper-mill pulp beaters from ¾-inch low-carbon plate 4 ft wide and 8 ft long.

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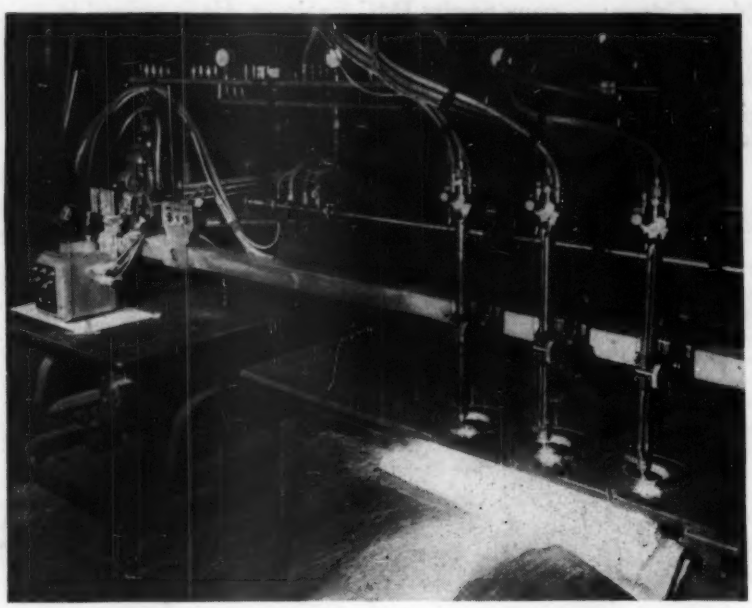
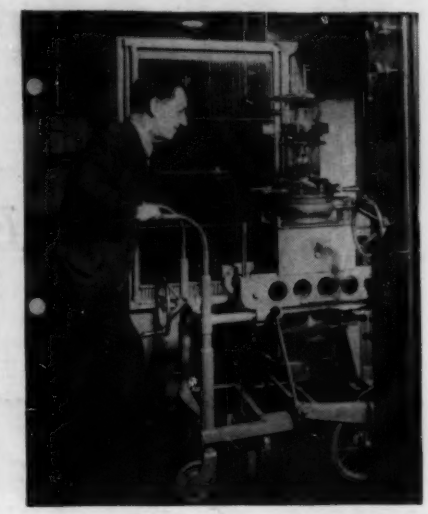
The electronic tracing device contains two phototubes, an amplifier tube, a lamp, associated circuit components and optical lenses, and three motors that control movement of the head—the steering motor, the tracer driving motor and a motor that raises or lowers the head in response to a manually operated switch. The tracing wheel controls the direction of movement of the head but does not track over the outline of the template except where it may intersect the outline.





Changing tubes is a touchy proposition when those involved cost about $5,000. Tubes are wheeled into position and lowered slowly into their sockets by truck mechanism

amperes peak current in the primary at a peak voltage of over 7,000. The modulation choke has an inductance of about 13 henrys at 14 amperes.

The final stage is a class C push-pull stage using two water-cooled tubes in a balanced bridge circuit. The filaments of these tubes carry 460 amperes at 32 volts, and their anodes are capable of dissipating 150 kw with voltages around 20,000. The tubes are 3 ft 6 in. high and they are wheeled in and out of the transmitter on special trolleys for safety in handling and ease of replacement.

Each transmitter is controlled from a small metal desk where the engineer may fire up his transmitter from a cold start and keep constant check on its efficient operation. Complete monitoring equipment is, of course, provided.

Power for the station is obtained from the Electricity Authority at 11 kv, 3-phase, 50 cps. Also, three 500-kw diesel-engine-driven alternators are available for emergency operation.

For some 22 hours a day, a radiated power of 1,500 kw is sent out to Europe and Asia, while from other beam networks services are transmitted to North America, Central and South America at night, and to the Fleet in the Pacific. The longest circuit on which direct transmission is achieved with ex-

(continued on p 136)

For the finest sound, just pick from this line...

755A—8" direct radiator, 8 watts, 70-13,000 cycles
756A—10" direct radiator, 20 watts, 65-10,000 cycles
757A—dual unit system, 30 watts, 60-15,000 cycles
728B—12" direct radiator, 30 watts, 60-10,000 cycles
754A—12" direct radiator, extra high efficiency, 15 watts, 60-10,000 cycles
754B—12" direct radiator, for outdoor use, 50 watts, 60-10,000 cycles

★ NO MATTER what your loudspeaker needs may be, one of these five Western Electric types will fit like a glove!

If you're looking for *superlative* reproduction, you can't beat the dual unit 757A, with its unequaled combination of efficiency, frequency response and power capacity.

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All types are available for immediate delivery. Call your nearest Graybar Representative or write to Graybar Electric Company, 420 Lexington Ave., New York 17, N. Y.

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THE ELECTRON ART

Edited by FRANK ROCKETT

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Radome Design Limitations 124
Series Overmodulation 126
Transitron Oscillator Tube 166
Survey of New Techniques 172

Tube Maps Magnetic Fields

PATHS OF MAGNETIC LINES of flux can be traced with a mercury vapor diode having a perforated tantalum (or other nonmagnetic) anode and a coaxial cathode. With an anode potential of 10 to 15 volts (approximately the ionization potential of the mercury) and a cathode current of about 10 ma (although operation is satisfactory over a wide current range), the electrons are focused into tight helical beams whose axes follow the magnetic flux paths even in fields as weak as 0.01 weber per square meter. Ionization of the vapor along the paths makes them visible.

The action of the tube, which is being studied by S. J. Tetenbaum under the direction of Prof. S. G. Lutz at New York University, can be seen from Fig. 1. Electrons from the cathode are accelerated toward the anode. Because of the magnetic field, only those electrons whose initial trajectories are nearly tangential to the magnetic flux continue undeflected through the perforations in the anode. The low radial velocities of these electrons enables the magnetic field to confine them to tight helical beams whose axes follow the magnetic flux paths quite accurately. The only cumulative distortion is a slight drift in the direction of the curvature axis of the field; it is minimized by the low electron velocity.

FIG. 1—Gas diode shows magnetic lines in flux; diameters of electron beams are least in regions of highest flux

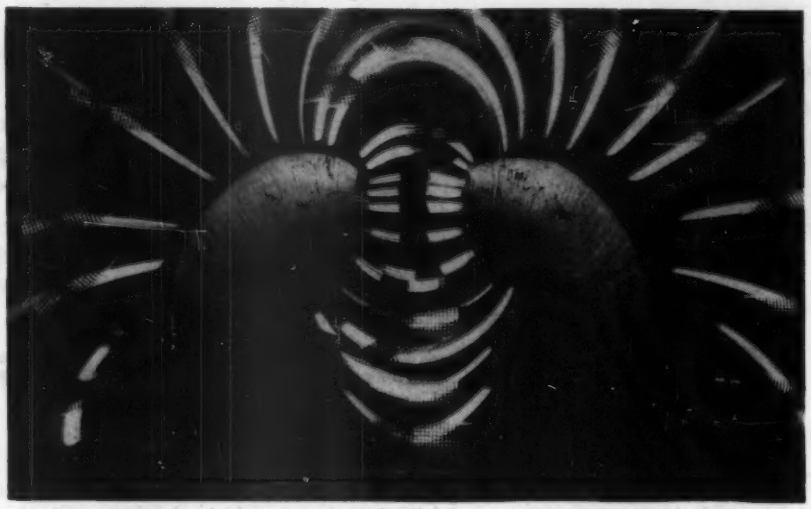

FIG. 2—Successive exposures with tube in various positions about a magnetron magnet (pole faces and shunt removed) show its field configuration; room lights, off during exposures, were turned on later to photograph magnet

The tube can be used to delineate leakages about magnetic structures or as a means of visually demonstrating the patterns of magnetic fields. By successively exposing a photographic film in a darkened room as the tube is moved about a magnet, the field can be mapped, as in Fig. 2. A paper describing this tube in greater detail was presented at the National Electronics Conference, Nov. 1948.

Radome Design Limitations

HOUSINGS for aircraft radar and radio antennas are often made of low-pressure molded plastic. The two conflicting requirements for the contours of these laminated structures, that they do not interfere (1) with the airfoil design of the airplane or (2) with the focusing of the radar beam, make their design and fabrication difficult. As pointed out by F. H. Behrens of the Air Materiel Command before a seminar of The Society of The Plastics Industry in June at Washington, D. C., the services and industries working on these problems have developed means for reconciling them to some extent.

Classification of Radomes

Radomes can be classified into types according to the constructional means used to minimize distortion of the radar beam. The radome absorbs appreciable power from the radiated field and also distorts it by reflection, refraction and diffraction. The radome may reflect sufficient energy back into the antenna to cause signal instability. At most radio frequencies the antenna housing is sufficiently thin compared to a wavelength to cause no distortion. However, at microwaves the thickness of the radome is comparable to a wavelength so that reflected and refracted energy from the inner and outer surfaces are not in a phase relation to produce cancellation.

There are four principal wall constructions in use: (1) thin wall, (2) thick wall, (3) double wall, and (4) sandwich. The sandwich construction is the most extensively used.

Thin walled construction is used

FM-AM SIGNAL GENERATOR

Type 202-B · 54-216 megacycles

The Accepted Standard of Performance!

In January, 1946, at the I. R. E. National Convention in New York City, a preliminary engineering model of the type 202-A FM-AM Signal Generator was displayed for the first time. Many well known FM and television engineers, invited to comment frankly on performance specifications, suggested refinements and features which they believed would be most desirable in the finished design.

Utilizing this valuable information, Boonton Radio Corporation's engineers worked another full year before they were ready to place their approval on the final design—the type 202-B FM-AM Signal Generator.

The advantages of this essential instrument were recognized immediately. Since its enthusiastic reception, the 202-B has increased in popularity and today it is generally accepted as the acknowledged standard of FM-AM signal generator performance. Practically every well known radio manufacturing concern is now placing increasing numbers of this versatile instrument in full time use, assisting their engineers and research staffs to design and produce better, lower cost radio and television receiving equipment.

If you have an FM or television instrument requirement, let us acquaint you with full particulars and technical data concerning the Type 202-B FM-AM Signal Generator. Write for Catalog F.

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DESIGNERS AND MANUFACTURERS OF THE Q METER • QX CHECKER
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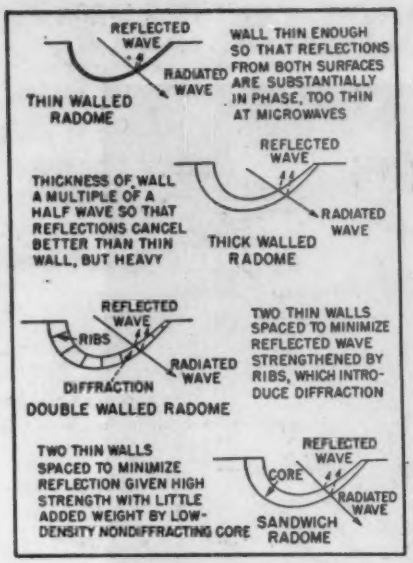

REFLECTED WAVE
RADIATED WAVE
THIN WALLED RADOME
WALL THIN ENOUGH SO THAT REFLECTIONS FROM BOTH SURFACES ARE SUBSTANTIALLY IN PHASE, TOO THIN AT MICROWAVES
THICKNESS OF WALL A MULTIPLE OF A HALF WAVE SO THAT REFLECTIONS CANCEL BETTER THAN THIN WALL, BUT HEAVY
REFLECTED WAVE
RADIATED WAVE
THICK WALLED RADOME
REFLECTED WAVE
RIBS
RADIATED WAVE
DIFFRACTION
DOUBLE WALLED RADOME
TWO THIN WALLS SPACED TO MINIMIZE REFLECTED WAVE STRENGTHENED BY RIBS, WHICH INTRODUCE DIFFRACTION
TWO THIN WALLS SPACED TO MINIMIZE REFLECTION GIVEN HIGH STRENGTH WITH LITTLE ADDED WEIGHT BY LOW-DENSITY NONDIFFRACTING CORE
REFLECTED WAVE
CORE
RADIATED WAVE
SANDWICH RADOME

Utility of airborne radar depends on the equipment having a suitable window through which to transmit its beam. Four types of radomes are commonly used to provide this window, but making them transparent and streamlined is difficult

at radio and longer microwave frequencies at which the wall thickness can be made small compared to a wavelength in the radome material. Such walls made thin enough for use at microwaves are structurally too weak for use in high-speed aircraft. At lower frequencies, where they can be made sufficiently thick for strength, thin walled housings are very satisfactory.

Structurally, the thick walled housings are similar to the thin walled types, but the thickness is made at multiples of a half wavelength in the dielectric so the reflections are neutralized. Because of the shape of the radome, the waves do not pass through all portions of the material at the same angle, so the thickness is a compromise or must be made variable. This type of wall is usually used at shorter microwaves; at longer wavelengths this construction gives an excessively heavy housing.

The double walled radome consists of two thin walls, one within the other, and accurately spaced to neutralize reflections by ribs that also increase its strength. Because of the poor strength and diffraction around the ribs, this type is little used.

The sandwich construction consists of two thin walls, one within the other as in the double walled type, but spaced and fully stabilized by a low density core material bonded between the thin skins. This arrangement neutralizes reflections and provides tremendous strength with low weight.

Streamlining and Transmission

Unless the radome is sufficiently streamlined it produces intolerable drag on a modern aircraft. Unless it presents sufficient undistorted transmission to the radar beam, the radome limits the accuracy of the radar equipment. Thus streamlining is limited by the critical angle of incidence at which the radar waves will pass through the wall. The relative orientation of the rays and the sloping surface of the radome establish this angle. The upper limiting angle of incidence is a function of the dielectric properties of the material used for the radome and of the wall configuration to which it is designed. In general, the lower the dielectric constant and the loss factor, the greater the freedom in streamlining.

A detailed study can be conducted to good accuracy to determine the angles of incidence and polarizing directions throughout the radome, thereby providing design data for grading the wall thickness. By this means an efficient, streamlined radome can be designed, but its final performance depends on the tolerance to which it can be molded.

Fabrication Limitations

Fabrication of radomes is beset by many problems and several improvements are necessary such as: (1) harder finishes that are less subject to erosion by rain, (2) close control of outline, thickness and uniformity of material, (3) elimination of lap joints in window areas of critical types of radomes, (4) fabrication of controlled graded thicknesses, and (5) elimination of hand tailoring of the core in various types of sandwich radomes.

The properties of laminated resins used for radomes need improvement also so that they will bond more strongly to glass fiber, withstand elevated temperature, have greater mechanical strength, lower dielectric constant and loss factor, and be sufficiently viscous so that voids will not form between laminations. Most current development is directed to improving sandwich domes. Voids are avoided by premolding skins which are then accurately supported during sandwich fabrication by molds. The core is introduced by heating a prepared foaming batter.

In conclusion, the speaker stated that the future of airborne radar depends to a great extent on satisfactory solution of these problems. (Ed. Note: see also Part II of "Radar Scanners and Radomes" by W. M. Cady, M. B. Karelitz, and L. A. Turner, vol 26, MIT Radiation Lab. Series, McGraw-Hill, 1948.)

Series Overmodulation

By ROBERT E. BAIRD
Chief Engineer, KWSC
Pullman, Wash.

Amplitude modulation in excess of 100 percent can be produced with a series modulator without creating sideband splatter. Several methods have been described for accomplishing such overmodulation (for example: Overmodulation Without Sideband Splatter, O. G. Villard, Jr., ELECTRONICS, p 90, Jan. 1947) and for exceeding 100 percent modulation on positive peaks without exceeding it on negative peaks. Broadcast stations in some localities overmodulate within the five-percent differential allowed by the FCC by slightly unbalancing their class-B linear amplifier. The simple method that is to be described here rounds the negative peaks so that overmodulation cannot occur on them even though over 200 percent modulation may be produced on positive peaks. In this way the break in the carrier that would cause sideband splatter is avoided.

Modulator Tube is Variable Resistor

Series modulation has considerable merit in itself because there are no reactances in the modulator. All that is needed is the proper tube and a power supply giving a little more than twice the rated voltage of the r-f amplifier. Figure 1A

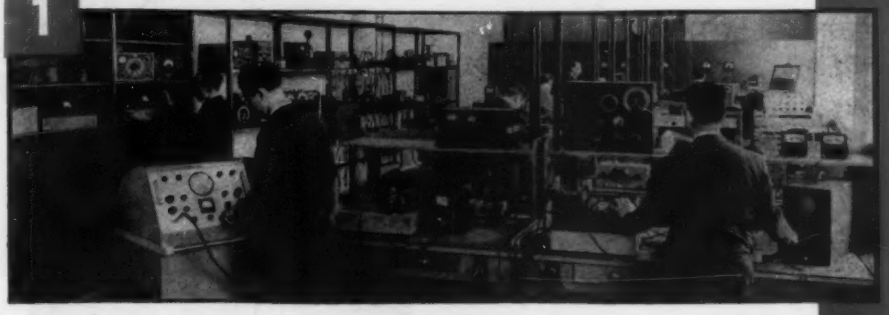
(Continued on p 160)

What we mean by...

RIGID QUALITY CONTROL

A DEFINITION OF SHERRON METHODS IN THE BUILDING OF CUSTOM MADE ELECTRONICS PROJECTS

1



HERE IN THE SHERRON electronics laboratory we initiate our design and development procedures. Every detail of a project's embryonic phase is explored by thoroughly seasoned physicists, engineers and technicians. Here the pattern for the finished product is accurately defined to assure trouble-free performance.

2

THE SHERRON electro-mechanical laboratory serves in the fabrication of mechanical components for . . . computers, vacuum tube structures, mechanical equipment for electronoptics, special precision wave guides, precision tuning units, precision drive mechanisms, servo mechanisms. Staffed by graduate mechanical engineers, equipped with the newest precision machines and tools, this laboratory is invaluable in closing up the margin for error in the electronic equipment we manufacture.

RECENT SHERRON PROJECTS INCLUDE

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- *Television — FM — AM — Transmitters*
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- *Ample Test Equipment to assure successful operation of above*

ELECTRONIC CONTROL EQUIPMENT FOR

- *Drone Aircraft Guided Missiles*
- *High Gain Amplifiers*
- *Computers and Calculators*
- *Servo Equipment*
- *Velocity Propagation measurement*
- *Test Equipment including Instrumentation for above*

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- *New applications for existing vacuum tubes*
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- *Vacuum tube voltmeter-ammeters*
- *Multi-wave shape generators*

TELEVISION

- *Television Signal Synthesizer Sync Generators*
- *Monoscope*
- *Shapers — Timers*
- *Wide band oscilloscopes*
- *Air monitors*
- *Field intensity equipment*
- *Television test equipment*

Sherron Electronics WZXDA

SHERRON ELECTRONICS COMPANY

Division of Sherron Metallic Corporation

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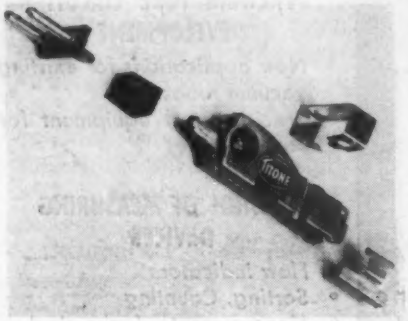
NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, tubes, testing apparatus and products closely allied to the electronics field. A review of catalogs, handbooks, technical bulletins and other manufacturers' literature

Ceramic Pickup

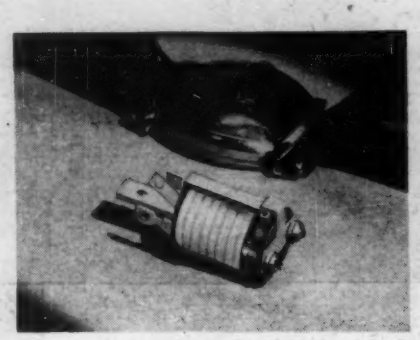
SONOTONE CORP., Elmsford, N. Y. Titone ceramic pickups for 78 and long-playing records use synthetic barium titanate piezoelectric elements. The pickup for 78-rpm records has a 0.0027-inch radius needle tip, requires a tracking weight of 22 grams, has a lateral compliance of 0.5 × 10^{-6} cm per dyne or better, and delivers an open-circuit output of 0.75 volt at 1,000 cps. The pickup for L-P records has a 0.001-inch radius needle tip, requires a tracking weight of



only 6 grams, has a lateral compliance of 0.75 × 10^{-6} cm per dyne, and delivers 0.25 volt at 1,000 cps on a test record. Both pickups have permanent sapphire needles and wide frequency responses. Mounting and electrical adapters are available so that the cartridge can be used in standard tone arms.

Supermidget Relay

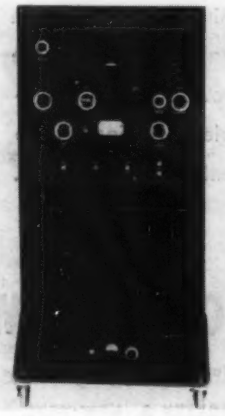
POTTER AND BRUMFIELD MFG. CO., 549 W. Washington Blvd., Chicago, Ill. A new type of miniature relay weighing only 0.33 ounce eliminates all nonfunctional parts. The core parts are formed to act as current-carrying elements and contacts, one part providing the armature and movable-contact arm while another



part is extended to provide a stationary contact arm and mounting. Another stationary contact can be mounted on the insulating bakelite front of the coil form with two screws. Contacts are heavy silver plating applied directly to the iron magnetic parts. They are rated for 100 milliamperes d-c at 50 volts for maximum life. Coils are wound to any desired resistance up to a maximum of 1,600 ohms.

Television Signal Standard

MEASUREMENTS CORP., Boonton, N. J. Model 90 television standard signal generator has a master oscillator, buffer, and modulated power amplifier. Output circuits are overcoupled to permit modulation frequencies up to 5 megacycles. Carrier range is continuously variable from 20 to 250 megacycles. Video modulation operating from a standard RMA composite signal has a bandwidth of 4 mc at 3 db. A mutual-inductance balanced attenuator is provided.



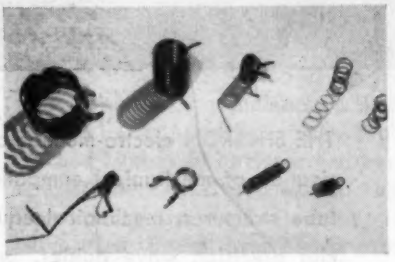
F-M Monitor

GRAYBAR ELECTRIC CO., 420 Lexington Ave., New York 17, N. Y. The Western Electric model 5A f-m frequency and modulation monitor provides continuous indication of center-frequency error, percentage of modulation, a visible alarm for

overmodulation, program monitor, and noise detector for measurement of transmitter a-m noise. Extension meters can be added. Write for brochure WECO-T2437.

Coils and Springs

WEBSTER SPRING CORP., 97 South 5th St., Brooklyn 11, N. Y. The coils and springs illustrated indicate the scope of the company's



manufacturing possibilities. In addition, solenoids and i-f transformers can be furnished on order in small or large quantities.

Submidget Switches

GENERAL CONTROL CO., 1200 Soldiers Field Road, Boston 34, Mass. New lever switches have shielding between switch assemblies and single-hole mounting or two sets of four holes on standard

WHY IT'S TO YOUR ADVANTAGE TO STANDARDIZE ON RAYTHEON SUBMINIATURE TUBES

For Special Purpose Applications

Raytheon Filamentary Subminiatures increase the salability of your product by decreasing its size. They are flat. Batteries can be little instead of big because of extremely low filament drain.

Raytheon Subminiatures plug into standard sockets, (over one and a half million in use), or can be soldered or welded into the circuit.

Raytheon Tubes are readily available from stock. Over half a million of the tubes described on this page are available at all times. They are standard throughout the world — more are in use today than all other makes combined!

Raytheon offers you unsurpassed application engineering service, backed by nine years of production and application experience.

→ NEW TYPES

This chart gives you at a glance the characteristics of representative Raytheon Subminiature Tubes

Type No.	Remarks	Maximum Diameter Inches	Maximum Length Inches	Filament Or Heater Volts	Filament Or Heater Ma.	Mutual Conductance Umhos	Power Output MW	TYPICAL OPERATING CONDITIONS Plate Volts	Plate Ma.	Screen Volts	Screen Ma.	Grid Volts
HEATER CATHODE TYPES												
CK5702/CK605CX	Characteristics of 6AK5	0.400	1.5	6.3	200	5000		120	7.5	120	2.5	−2.0
CK5703/CK608CX	Triode, UHF Oscillator, ⅓ watts at 500 Mc	0.400	1.5	6.3	200	5000		120	9.0			−2.0
CK5704/CK606BX	Diode, equivalent to one-half 6AL5	0.315	1.5	6.3	150			150ac	9.0			
CK5744/CK619CX	Triode, High mu.	0.400	1.5	6.3	200	4000		250	4.0			−2.0
→ CK5784	Characteristics of 6AS6	0.400	1.5	6.3	200	3200		120	5.2	120	3.5	−2.0
FILAMENT TYPES												
2E31-32	RF Pentode for pocket radio	0.300x0.400	1.56	1.25	50	500		22.5	0.4	22.5	0.3	0
2E35-36	Output Pentode for pocket radio	0.290x0.390	1.56	1.25	30	385	1.2	22.5	0.27	22.5	0.07	0
2E41-42	Diode Pentode for pocket radio	0.290x0.390	1.56	1.25	30	375		22.5	0.35	22.5	0.12	0
2G21-22	Triode Heptode for pocket radio	0.300x0.400	1.56	1.25	50	75 conv. cond.		22.5	0.20	22.5	0.30	
RK61	Gas Triode, Exp. Radio Control	0.550	1.81	1.4	50			45.0	1.5	Special Circuit		
CK502AX	Output Pentode	0.285x0.385	1.5	1.25	30	550	6.0	45.0	0.6	45.0	0.15	−1.25
CK503AX	Output Pentode	0.285x0.385	1.5	1.25	30	550	9.5	45.0	0.8	45.0	0.25	−2.0
CK505AX	Voltage Amp. Pent.	0.285x0.385	1.5	0.625	30	38†		22.5	0.125	22.5	0.04	−0.625
CK506AX	Output Pentode	0.285x0.385	1.5	1.25	50		25.0	45.0	1.25	45.0	0.40	−4.5
CK510AX	Double Space Charge Tetrode Amplifier	0.285x0.400	1.25	0.625	50	150† both units		45.0	0.06			0
CK512AX	Low microphonic voltage amplifier	0.285x0.385	1.25	0.625	20	37†		22.5	0.125	22.5	0.04	−0.625
CK522AX	Output Pentode 20 ma. filament	0.285x0.385	1.5	1.25	20	450	1.2	22.5	0.30	22.5	0.08	0
CK523AX	Output Pentode	0.285x0.385	1.5	1.25	30	360	2.5	22.5	0.30	22.5	0.075	−1.2
CK524AX	Output Pentode	0.285x0.385	1.5	1.25	30	300	2.2	15.0	0.45	15.0	0.125	−1.75
CK525AX	Output Pentode	0.285x0.385	1.5	1.25	20	325	2.2	22.5	0.25	22.5	0.06	−1.2
CK526AX	Output Pentode	0.285x0.385	1.5	1.25	20	400	3.75	22.5	0.45	22.5	0.12	−1.5
CK527AX	Output Pentode 15 ma. filament	0.285x0.385	1.5	1.25	15	225	0.75	22.5	0.10	22.5	0.025	0
CK529AX	Shielded Output Pentode	0.290x0.390	1.5	1.25	20	275	1.2	15.0	0.20	15.0	0.05	−1.5
→ CK533AX	Output Pentode	0.285x0.385	1.5	1.25	15	425	2.0	22.5	0.4	22.5	0.1	0
→ CK535AX	Output Pentode	0.285x0.385	1.5	1.25	20	275	1.2	15.0	0.20	15.0	0.05	−1.5
CK551AXA	Diode Pentode	0.300x0.400	1.56	1.25	30	235		22.5	0.17	22.5	0.043	0
CK553AXA	RF Pentode	0.300x0.400	1.56	1.25	50	550		22.5	0.42	22.5	0.13	0
CK571AX	10 ma. Filament electrometer tube, Ig = 2×10^{-15} amps.	0.285x0.400	1.5	1.25	10	1.6†		10.5	0.20			−3.0
→ CK573AX	Triode, high frequency output	0.300x0.400	1.5	1.25	200	2000		135	14.0			−7.5
→ CK574AX	Shielded Pentode RF Amplifier	0.290x0.390	1.25	0.625	20	37†		22.5	0.125	22.5	0.04	−0.625
CK5672	Output Pentode	0.285x0.385	1.5	1.25	50	625	60.0	67.5	2.75	67.5	1.1	−6.25
CK5676/CK556AX	Triode, UHF Oscillator for radio use	0.300x0.400	1.5	1.25	120	1600		135.0	4.0			−5.0
CK5677/CK568AX	Triode, UHF Oscillator for radio use	0.300x0.400	1.5	1.25	60	650		135.0	1.9			−6.0
CK5678/CK569AX	RF Pentode	0.300x0.400	1.5	1.25	50	1100		67.5	1.8	67.5	0.48	0
CK5697/CK570AX	Electrometer Triode Max. grid current 5×10^{-15} amps.	0.285x0.400	1.25	0.625	20	1.5†		12	0.22			−3.0
→ CK5785	High voltage rectifier	0.285x0.400	1.5	1.25	15				0.1	Inverse peak 3500 volts		
VOLTAGE REGULATORS												
→ CK5783	Voltage reference tube — like 5651	0.400	1.63	Operating voltage 85. Operating current range 1.5 to 3.5 ma.								
→ CK5787	Voltage regulator	0.400	2.06	Operating voltage 100. Operating current range 5 to 25 ma.								

CK ® RK ®

†Voltage Gain (times)

NEW — Write for Socket and Mounting Notes for Flat Press Subminiature Tubes.

RAYTHEON MANUFACTURING COMPANY

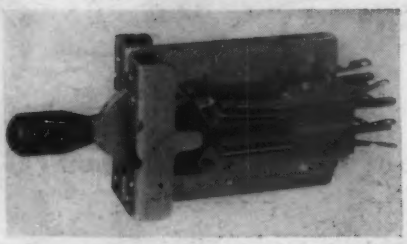
SPECIAL TUBE SECTION

Newton 58, Massachusetts

RADIO RECEIVING TUBES • SUBMINIATURE TUBES • SPECIAL PURPOSE TUBES • MICROWAVE TUBES

RAYTHEON

Excellence in Electronics



centers. Total depth of the frame behind the panel is 2½ inches to 2 21/32 inches depending upon the contact arrangement.

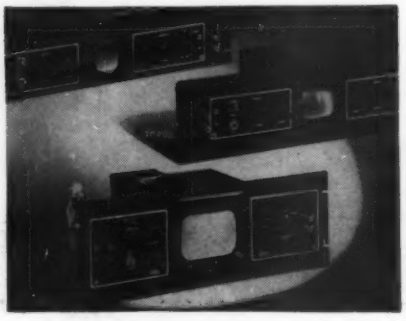
Bus Receiver

GENERAL ELECTRIC Co., Syracuse, N. Y. The f-m fixed-tuned receiver shown is used in buses or other vehicles that are a part of the programming-advertising combination sometimes known as "car-card radio". Crystal controlled at the fre-

quency of the desired station, the receiver operates from the bus battery, is connected to four or eight speakers, and is used with a dipole mounted externally over the driver's seat.

Basic Oscilloscopes

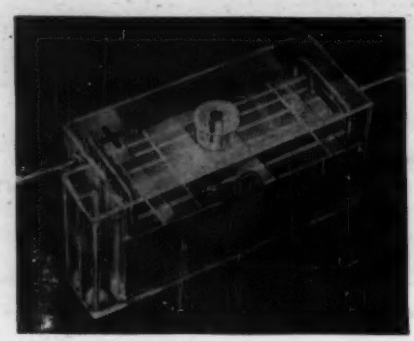
JAMES MILLEN MFG. Co., INC., Malden, Mass. The three models of rack panel oscilloscopes have been designed as basic units to which



other units, such as sweep circuits, pulse generators, and amplifiers can be added for any laboratory or industrial use. Models 90902, 90903, and 90905 use two-, three,- and five-inch tubes, respectively.

Small Wet Cell

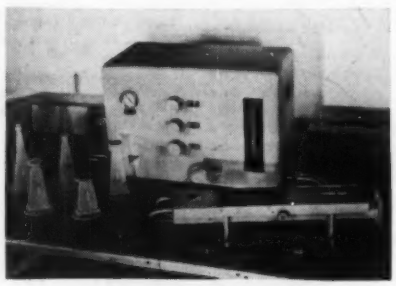
THE VITAMITE Co., 227 West 64th St., New York 23, N. Y. A new rechargeable nonspill wet-cell battery model 2A-3.00 weighs six ounces. It has a four-ampere capacity and



has been designed to operate under low-temperature and low-pressure conditions.

Microwave Calorimeter

DE MORNAY BUDD INC., 475 Grand Concourse, New York 51, N. Y. Measurement of absolute r-f power in a series of frequency bands between 2,600 and 26,500 megacycles



is now possible. Accuracy of 2 watts at average power readings of 100 to 500 watts is attained by the calorimetric principle.

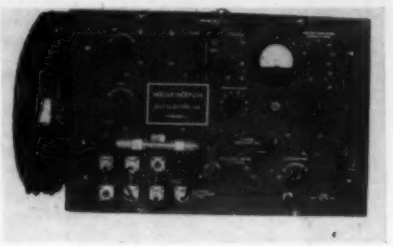
Educational F-M

GENERAL ELECTRIC Co., Syracuse, N. Y. A new f-m broadcast transmitter type BT-11-B operates in the 88-to-108-megacycle range, but is designed for a power output of ten watts or less for noncommercial

educational work. Coverage ranges from 5 to 10 miles depending upon the installation. The unit employs a Phasitron modulator, has 21 tubes, and weighs 280 pounds.

Standing-Wave Meter

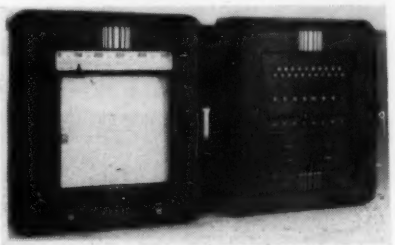
KAY ELECTRIC Co., Pine Brook, N. J. The modified Megamatch displays reflected energy in bandwidths of 30 mc anywhere between



10 and 500 mc, and can be used for most work up to 1,000 mc. Price of the modified unit, which uses a special coaxial detector and delay line, is $895 f.o.b.

Multiple Recorder

LEEDS AND NORTHRUP Co., 4934 Stenton Ave., Philadelphia 44, Pa. A new Speedomax recorder automatically logs as many as 160 separate thermocouple temperatures in succession at a rate of 4



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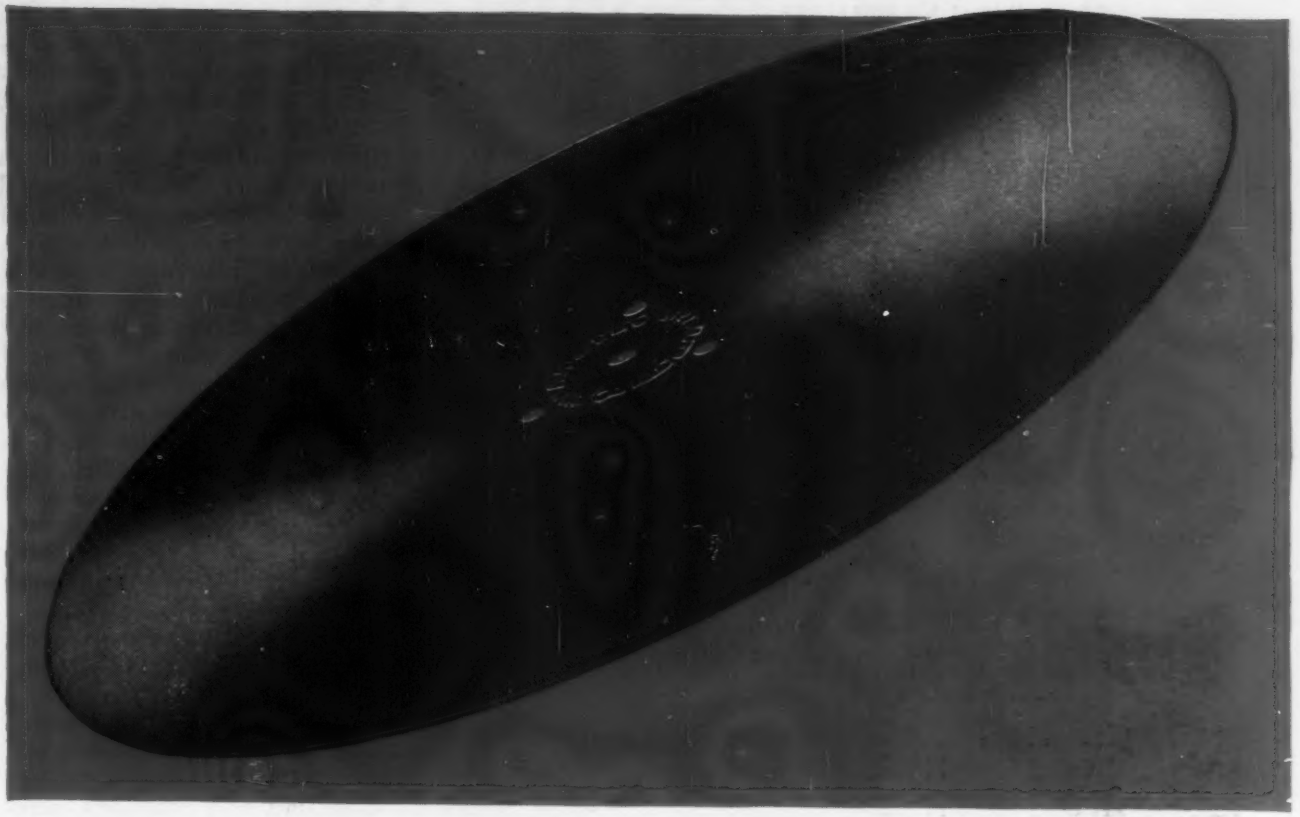
FOR FINER ALL-WEATHER RECORDING



Now audiodisc* *lacquer provides permanent resistance to humidity*

Excessive humidity has long been one of the industry's major problems—both to the manufacturer and to the recordist. Humid conditions in factories have frequently held up production and caused excessive spoilage. Also, discs which have absorbed too much moisture make poor recordings. The noise level increases progressively while recording and the cut gets greyer and greyer.

Air conditioning has been tried by several producers, but this does not prevent moisture absorption during transportation and storage. The real solution lies in the formulation of a lacquer which will provide permanent resistance to humidity. This has now been successfully accomplished by our research laboratory. Here are the facts:

1. The Improved Audiodisc Formulation has eliminated all production difficulties due to excessive humidity. During the past summer no trouble was encountered, even with humidity as high as 90%.

2. Countless Tests in our "weather room" have proved the new Audiodiscs to be remarkably resistant to moisture absorption. Discs subjected to a temperature of 90° at 80% to 90% humidity for many weeks show no increase in noise level while recording. Ordinary discs, under the same conditions, show a noise level increase of from 15 to 25 db. The most conclusive proof of all, however, has come from the field—for during the past summer, one of the most humid on record, our customers have reported no difficulties in recording or reproduction due to humid conditions.

3. This "Weather-Proof" Feature has been achieved without any basic change in our lacquer formulation. Recordists will therefore continue to note the outstanding qualities in recording, playback and processing which have made for Audiodisc leadership.

•

This improved humidity-resistant lacquer is now used on all Audiodiscs. It is your assurance of finer, all-weather recording—with the same consistent, uniform quality which has characterized Audiodiscs for a decade.

*Reg. U. S. Pat. Off.

Audiodiscs are manufactured in the U.S.A. under exclusive license from PYRAL, S.A.R.L., Paris.

Audio Devices, Inc., 444 Madison Ave., N.Y.C.

Export Dept: Rocke International, 13 East 40th Street, New York 16, N. Y.

they speak for themselves audiodiscs

NEWS OF THE INDUSTRY

Edited by WILLIAM P. O'BRIEN

Magnetic recording standards; train television demonstrated; FCC abandons operator license changes

Park Strollers View World Series

Baseball fans unable to get into the ball park view opening game of World Series over RCA television sets installed by that company on Boston Common. Telecast was from WBZ-TV, Brighton, Mass., with microwave relay and coaxial cable providing feed from the master receiver atop the Ritz Carlton Hotel

ONE of the largest group installations of television sets ever made brought the recent World Series to an estimated 100,000 viewers on Boston Common. Over one hundred RCA Victor 721TS receivers with 52-sq-in. screens were set up by RCA Service Company technicians.

For this mass installation of sets, a special receiver was installed atop the Ritz Carlton Hotel to pick up the telecast from WBZ-TV and feed a microwave transmitter that beamed the program directly to the control tent on the Common. A five-foot-diameter parabolic reflector on the hotel roof was aimed at a similar dishpan atop the control tent to provide ghost-free and interference-free transmission to the sets at the tent. The signal was converted back to a standard television signal and fed through a total of three miles of coaxial cable to the 100 individual sets.

Each set was mounted on a 7½-ft stand with a special shadow box to cut down sunlight, so that as many as a hundred people at a time were able to sit and stand in front of each set and view the game satisfactorily despite full daylight.

Ultrafax Progress Report

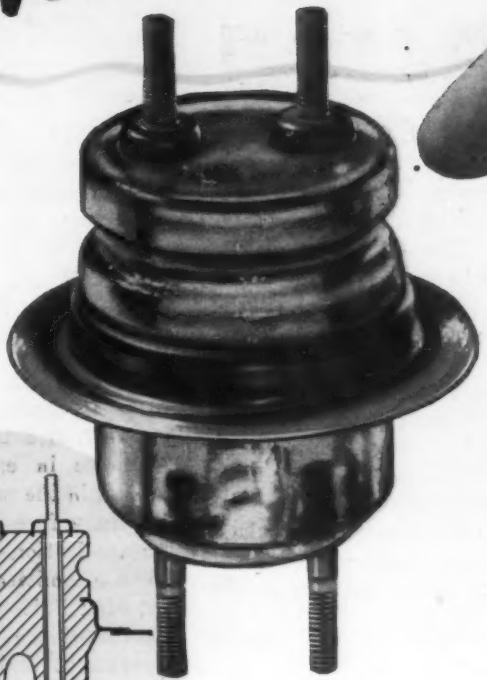
THE PRESENT status of a new technique for transmitting enormous quantities of written, printed, or drawn material in an extremely short time was demonstrated by Radio Corporation of America at the Library of Congress, Washington, D. C., on October 21, 1948. The system shown consists of a somewhat unconventional scanning device employing a flying-spot cathode-ray tube and a photomultiplier tube, a 7,000-megacycle relay link, and a projection kinescope at the receiving end to expose a 16-mm moving film. The experimental transmitter uses a 35-mm film on which is recorded the desired intelligence. An important feature of the system is the rapid development of the film at the receiver. For demonstration purposes a small unit built by Eastman Kodak was used that moved the exposed film through a hot developing bath, delivering a dry positive film, suitable for viewing, in 40 seconds. Already developed but not demonstrated is a three-channel machine for printing up enlarged paper copies of the received messages.

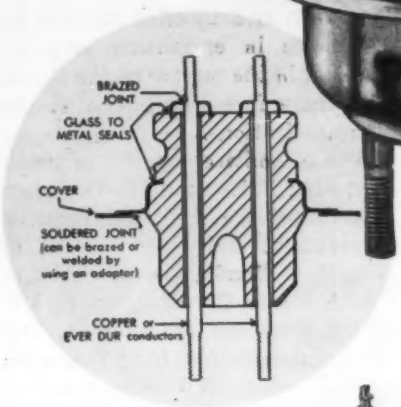
To date, the photographic aspect of the system lags somewhat behind the electronic equipment which is essentially simpler and represents the refinements of known techniques. However, certain developments, such as a flying-spot scanner with a narrow beam have been essential. The radio transmission speed was pointed up by the transmission of the whole of the book, "Gone with the Wind" page by page, in two minutes and twenty-one seconds. Photographing the pages and reprinting them at the receiver would take substantially longer.

The functioning of the system on

Donald S. Bond, RCA Laboratories, Ultrafax project engineer threads film to be transmitted between the flying-spot scanner (left) and the photomultiplier tube (in light-tight box beneath his left hand)

Glass bushings Now Available



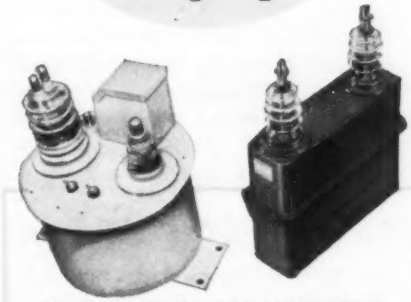

BRAZED JOINT
GLASS TO METAL SEALS
COVER
SOLDERED JOINT (can be brazed or welded by using an adapter)
COPPER or EVER DUR conductors

to manufacturers of electronic equipment

Can be welded, brazed, or soldered to case, forming a strong, permanent, hermetic seal that eliminates moisture problems and often permits more compact, light-weight design.

General Electric is now offering to other manufacturers the glass bushings that it has used so successfully on capacitors, rectifiers, modulator and instrument transformers, and other electrical equipment. These bushings are cast of an exceptionally stable, low-expansion glass. Metal hardware is a special nickel-alloy steel, fused to the glass in casting. Bushings are attached directly to the apparatus without gaskets—by soldering, welding or brazing the metal bushing flange to the metal case.

The resulting joint between bushing and equipment is permanent, vacuum-tight, and of high mechanical strength. It is especially desirable for equipment subject to vibration, shock, fungus growth or severe changes in temperature. These glass bushings are currently available to meet dry, 60-cycle, flashover values of from 10 to 50 kv, and in current ratings of 25 and 50 amperes (large sizes up to 800 amperes). They may be single or multi-conductor and can be provided with a top flange to permit mounting tube sockets directly on the bushings. Diameters range from $1\frac{5}{8}$ to $3\frac{3}{8}$ inches and weights from $2\frac{1}{2}$ oz. to 4 lb.



The best way to evaluate these glass bushings for capacitors, modulator transformers, and other electronic equipment, is to see them. If you will send us a sketch and ratings of bushings you are now using, we will furnish you with samples of one or more of our standard glass bushings. Or write for Bulletin GEA-5093 which contains complete listings of our standard designs, allowing you to select the particular bushing you require. ***Power Transformer Sales Division, General Electric Co., 16-215 Pittsfield, Mass.***

GENERAL ELECTRIC

401-68

an economic basis is predicated upon the establishment of nationwide microwave relay links also necessary for television. It was suggested that transatlantic service might begin soon if government services could maintain a chain of relay airplanes, spaced about every 200 miles between North America and Europe.

Although the reproductions obtained at the receiver were reasonably good, it has been pointed out that greater clarity and a goal of "a million words a minute" will only be possible using bandwidths of 10 megacycles as compared with the five-megacycle width employed for demonstration purposes.

MEETINGS

NOV. 29–DEC. 1: Conference on electronic instrumentation in nucleonics and medicine, sponsored by IRE and AIEE, Engineering Societies Building, New York City.

NOV. 29–DEC. 4: 18th National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York.

DEC. 10–11: Southwestern IRE Conference, Baker Hotel, Dallas, Texas.

JAN. 10–12: Symposium on high-frequency measurements, held by Instruments and Measurements Committee jointly with the IRE and National Bureau of Standards, at Washington, D. C.

MARCH 7–10: IRE annual convention, Hotel Commodore and Grand Central Palace, New York City.

APRIL 11–15: Sixth Western Metal Congress and Exposition, Shrine Auditorium, Los Angeles, Calif.

MAY 16–20: Radio Parts Industry Trade Show and RMA Silver Anniversary Convention, Hotel Stevens, Chicago.

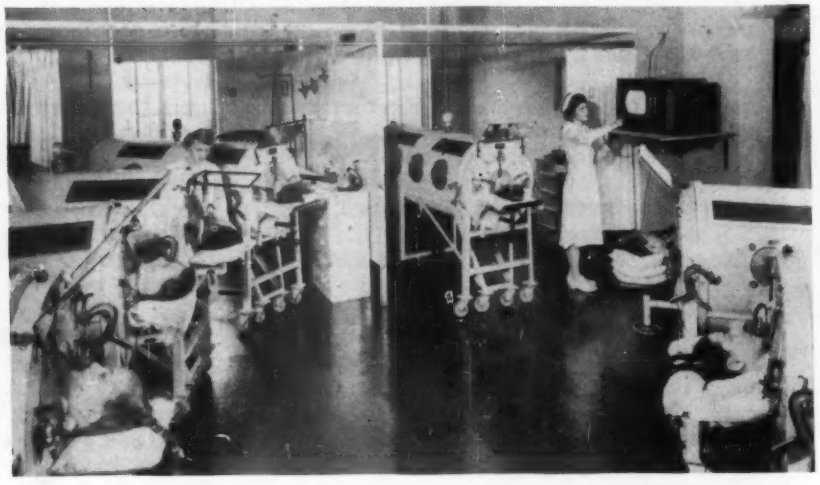
Magnetic Recording Standards

ANNOUNCEMENT OF a proposal of three recording speeds for magnetic tape was recently made by the National Association of Broadcasters' Recording and Reproducing Standards Committee. The group's proposal involves adoption of a primary standard magnetic tape speed of 15 inches per second for a frequency response of 50 to 15,000 cycles, a secondary standard of 7.5 inches per second for a frequency response of 50 to 7,500 cycles and a supplemental standard of 30 inches per second for all wide-range standards. The latter essentially corresponds to the European standard 77 mm (30.318 inches) established by the German magnetophone.

The committee also agreed that the minimum playing time per reel should be 33 minutes. Maximum permissible noise level was set at 40 db below peak signal level. Zero db level was set at 2-percent distortion.

It is expected that the standards will be ready for submission to the NAB board of directors for final adoption at the regularly scheduled November meeting.

Hospital Television



Nurse tunes in television receiver, a gift of the Baltimore Rotary Club, while iron lung patients watch their individual mirrors

POLIO victims in an iron lung ward at the Baltimore Children's Hospital School recently had installed for them a Stromberg-Carlson 12-inch screen television receiver. Special mirrors were erected above the patients' heads so that all could see the screen.

Industry to Present Views to FCC

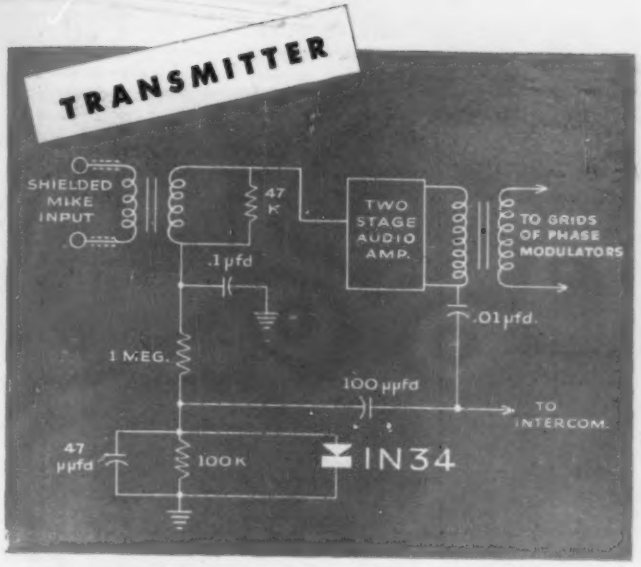
THE RMA has appointed a committee to confer with FCC Chairman Coy, and to offer the RMA's assistance in expediting an FCC decision in the matter of the recent temporary freeze on television station applications.

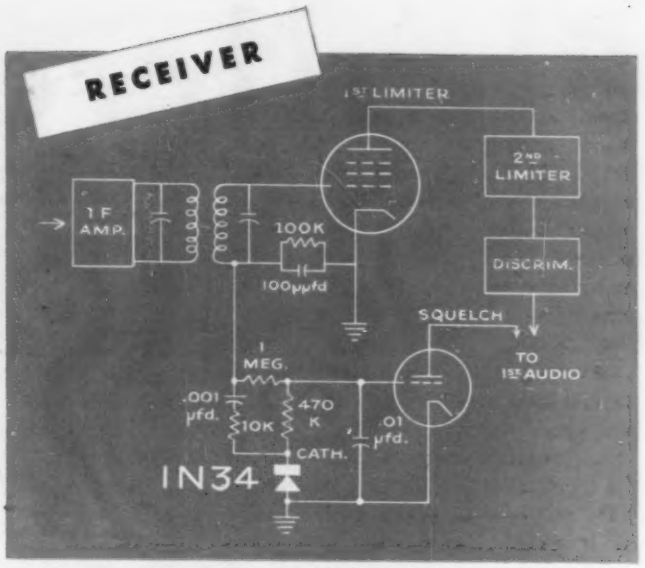
The committee consists of president Max Balcom; W. R. G. Baker, director of the RMA Engineering Department and vice-president of GE; H. C. Bonfig, vice-president of Zenith Radio Corp.; Allen B. DuMont, president of Allen B. DuMont Laboratories, Inc.; Frank W. Folsom, executive vice-president of RCA Victor; Paul V. Galvin, president of Motorola Inc.; and L. F. Hardy, vice-president of Philco Corp.

Radio Network for Farmers

AN F-M network with no wires whatsoever, known as the Rural Radio Network Inc., has been established by ten farm organizations to serve about 118,000 farms in New York State. Stations are linked together only by direct radio pickup of each other's programs. Stations now on the air, with frequency assignments and distance to the adjacent station they feed or

(Continued on p 217)





IN THE TRANSMITTER, a Type 1N34 SYLVANIA GERMANIUM DIODE rectifies the audio modulating voltage, to provide a variable d-c bias for automatic gain control. Use of such a circuit helps prevent over-modulation while maintaining a high average audio level. The result —voices of the train crews are transmitted clearly, evenly.

IN THE RECEIVER, another SYLVANIA GERMANIUM DIODE, Type 1N34, provides a delayed noise-gate action which suppresses undesired noise interference in the receiver output. Hence, only signals of usable amplitude will actuate the squelch circuits and the receiver is kept essentially silent in the absence of a carrier.

SYLVANIA GERMANIUM DIODES...

IMPROVE PERFORMANCE OF FARNSWORTH VHF RAILROAD COMMUNICATIONS EQUIPMENT!

Use of Sylvania Germanium Diodes may improve the performance of *your* equipment, too—or simplify its design, reduce its size and weight. Technical literature is available to help you start your planning.

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Gentlemen:

Please send me your literature on Germanium Diodes and Duo-Diodes, including the series of Engineering News Letters showing their applications in television circuits.

I am also interested in receiving literature covering applications of your other products in the fields of (check one):

☐ *Communications and Industrial Electronics*
☐ *Radioactivity*
☐ *Radar and Microwaves*

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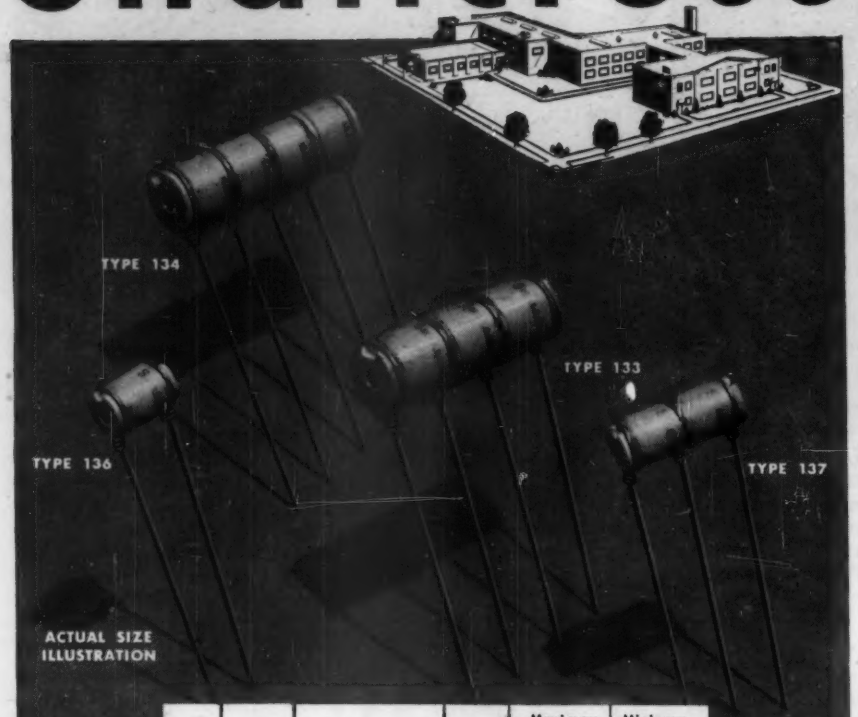
Shallcross



Type	Sections	Size	Watts	Maximum Resistance per section Ohms	Minimum Resistance per section Ohms
136	1	13/32" x 1/4"	0.25	150,000	1.
137	2	45/64" x 1/4"	0.25	150,000	1.
133	3	1-5/32" x 3/8"	0.25	550,000	1.
134	4	1-1/4" x 3/8"	0.25	375,000	1.

AKRA-OHM PRECISION RESISTORS

for "miniaturization" programs

These new Shallcross Akra-Ohm Wire-Wound Precision Resistors have been designed to meet the needs of modern, miniature equipment. Standard tolerance is 1% and closer tolerances can be furnished on special order.

The units offer unusually high and accurate resistance values in small space and are light enough to be suspended by their own tinned copper leads, or may be secured with mounting screw.

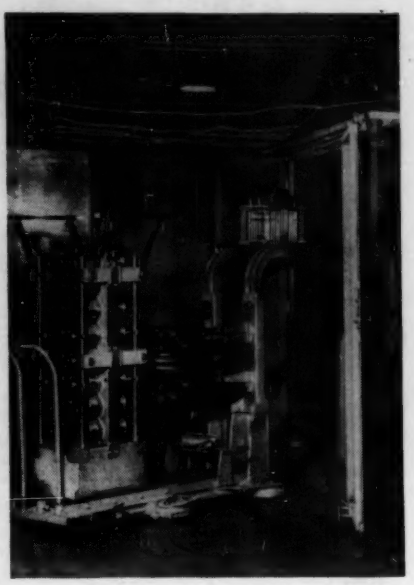
Other Shallcross Akra-Ohm Precision Resistors include types, shapes, mounting arrangements and ratings for every close-tolerance requirement and are designed to meet JAN specifications. Write for Bulletin RG, giving complete precision resistor data in convenient chart form.

Complete Service measurement facilities
IN A SINGLE INSTRUMENT

The improved Shallcross 614-A Service meter covers a wide range of measurements. These include d-c and a-c voltage, capacitance, and d-c resistance. Also it can be used for approximating an artificial load. Auxiliary scales provide an inductance range of 1 to 100; 1,000, 10,000 henries, and an a-c resistance range of 25 ohms to 3 megohms. Only two switches are used for 25 ranges. The instrument is self-contained, housed in a metal case with handle and weighs only 12½ lbs. Write for details.

SHALLCROSS MANUFACTURING COMPANY
Dept. E-128, Collingdale, Penna.

(continued from p 122)



Band and frequency changing is expedited by the use of mobile tank circuits. A rail system guides trucks accurately to their contacts in the transmitter cabinet

cellent results at the receiving end is 14,000 miles using a 100-kw channel, the full output of one transmitter. The average shutdown time since the station was commissioned in 1943 has been less than 0.04 percent.

Graphical Iron Core Reactor Design

By Morton R. Whitman
Engineering Department
Thordarson Electric Manufacturing Division
Chicago, Illinois

Reactor designers are usually plagued by the mutually hostile requirements of speed and an optimum balance of the parameters involved in the design of reactors which carry both direct and alternating currents.

An optimum balance means the use of readily available parts and standard production techniques, a minimum of material in construction, low operating noise level and good thermal and insulation characteristics.

The principal difficulty in this problem arises from the nonlinearity of the magnetic material used in core structures. This makes impossible the derivation of an explicit formula which could give accurately say, the size and weight of a specified reactor. The purpose

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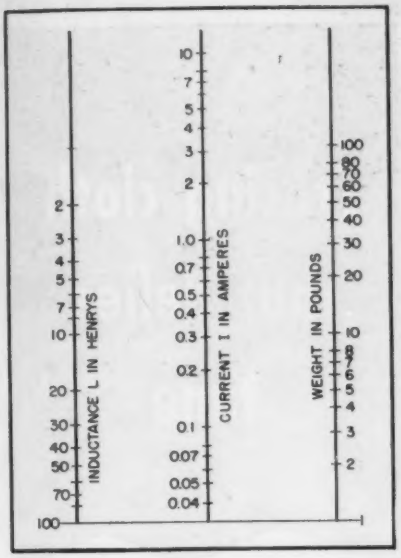

FIG. 1—Alignment chart which may be altered to give actual design figures by reference to data on an arbitrarily selected prototype unit and appropriate vertical displacement of vertical axes

here is to suggest empirical techniques for doing these things.

Model theory offers a useful approach to this problem. It generalizes the results obtained on a sample and makes possible, in effect, the extrapolation of the data so obtained. The precision of data obtained in this way depends on how accurately a unit holds to scale with this sample, or prototype. Nevertheless, even if the scale factor is omitted from consideration, the results are significant from a design point of view.

An important result of the kind discussed is the relation: weight equals kLI^2 where weight is that of either core iron or total core and coil weight (adjustment of the constant k can be performed to suit one requirement or the other since in a line of geometrically similar reactors the winding weight will be a relatively fixed percentage of total core and coil weight); L is the inductance, and I is the direct current in the winding. An alignment chart is presented in Fig. 1 to expedite use of this relationship. The chart is not intended to give actual design figures but can be made to do so by reference to the data on an arbitrarily selected prototype unit and appropriate vertical displacement of the axes. Greatest accuracy can be secured by choosing as prototype

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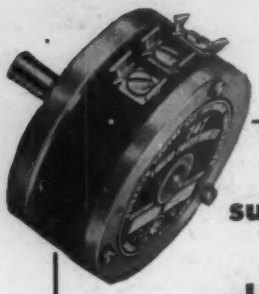

long life
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low noise level
absolute resolution
resetability
multiple ganging

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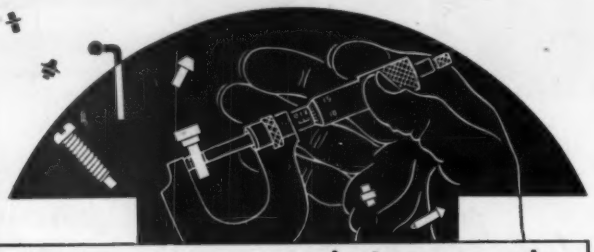

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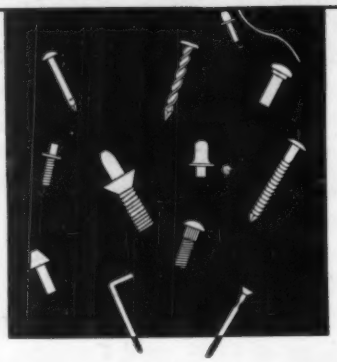

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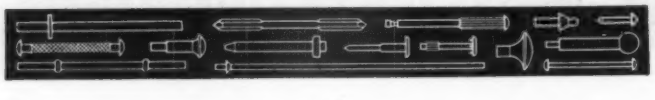

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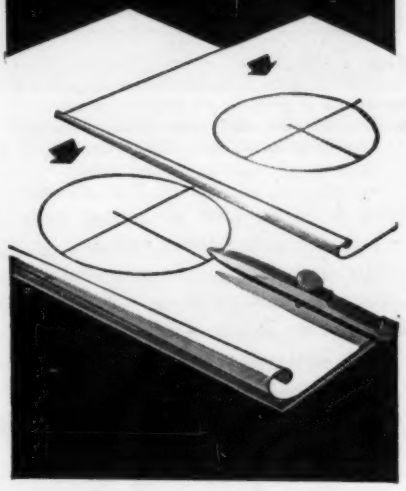

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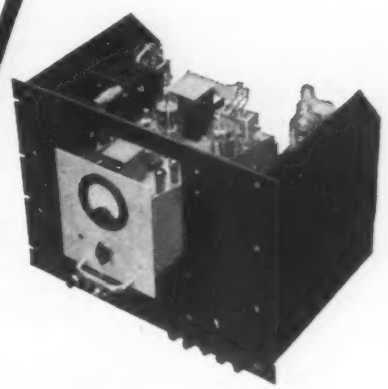

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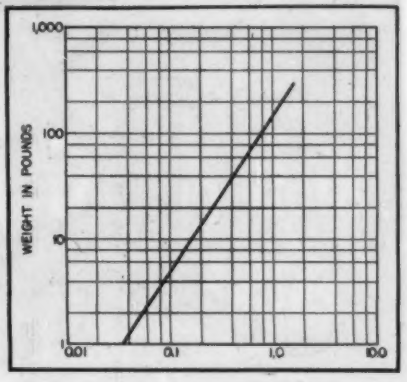

FIG. 2—Design curve for finding weight of a single reactor unit from the reactor time constant, L/R

a unit somewhere in the desired range of size and weight.

A second relation gives the weight in terms of the time constant, L/R, of the reactor. Here, R is the simple ohmic resistance of the winding—L/R equals $KW^2/3$. The form of this equation makes graphical representation very simple. Measurements of the time constant and the weight on a single unit are used as the co-ordinates of a point on log-log paper. A straight line drawn through this point with a slope equal to $\frac{3}{8}$ completes the graph. A typical curve is shown in Fig. 2.

The curves must be used with caution since generally they are valid only when conditions of similarity to the prototype are maintained. Varying insulation requirements, cooling considerations and other considerations introduce error. Nevertheless, the curves are useful for estimating purposes and for reducing the number of steps in the preliminaries to actual design.

Filter reactors for use with polyphase rectifier systems operate at considerably lower excitation levels than corresponding single-phase systems for the same output voltage. Since permeability is an increasing function of the excitation up to some maximum characteristic of the material used, the polyphase filter reactor will in general be different from the single-phase unit. The difference will not be so large, however, that the charts will not be of some use for both.

An illustration of the use of the curves will be given here. Assume we wish to design a reactor of 5 henrys at 1 amp d-c. The insula-

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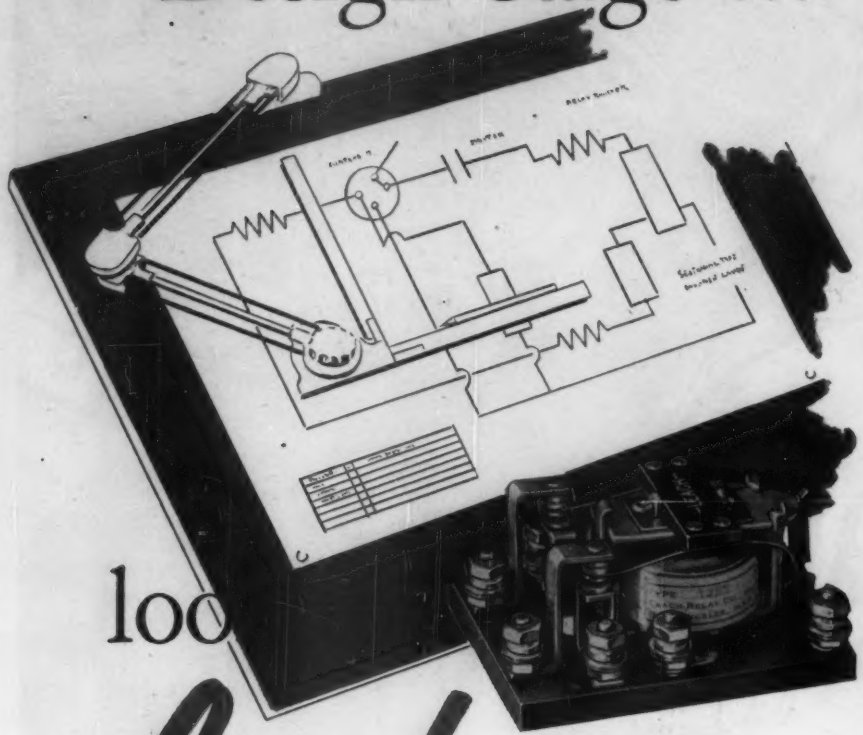

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tion level, excitation and thermal characteristics will be neglected to illustrate the technique.

From Fig. 1, the weight will be 47 pounds. From Fig. 2 the time constant will be 0.46. Hence, the nominal resistance will be 5/0.46 or approximately 11 ohms. On the basis of the information now available the required lamination size is readily determined.

A square center leg cross-section will give minimum length of turn for the winding for a given cross-section area so that using minimum copper weight as a criterion the lamination size may be picked out from a table of lamination sizes and weights per square stack. Since the resistance is known, the number of turns in the winding may be readily determined in terms of the mean length of turn for the core size chosen. The design may then be refined by consideration of the factors which have been omitted up to this point. In most instances only relatively slight changes will be required.

Remote Control for Radio Tuning

By S. Wald

Aviation Equipment Engineering
Engineering Products Department
Radio Corporation of America
Camden, New Jersey

A noticeable trend in architecture and planning for modern homes is the increased use of built-in broadcast receivers. Their popularity has encouraged the author to investigate the possibilities of remote tuning devices and their application to standard broadcast receivers. The unit discussed in subsequent text and illustrated in the accompanying diagrams has been found to be highly effective, providing for both push-button and continuous remote tuning.

The schematic of the system is shown in Fig. 1. Alternating plate and grid voltages are applied to two miniature thyratrons in a push-pull circuit. The voltage between grid and cathode of each tube lags the corresponding plate voltage by approximately 115 degrees. Thus, each tube fires during a little less than one-half of the positive plate voltage excursion.

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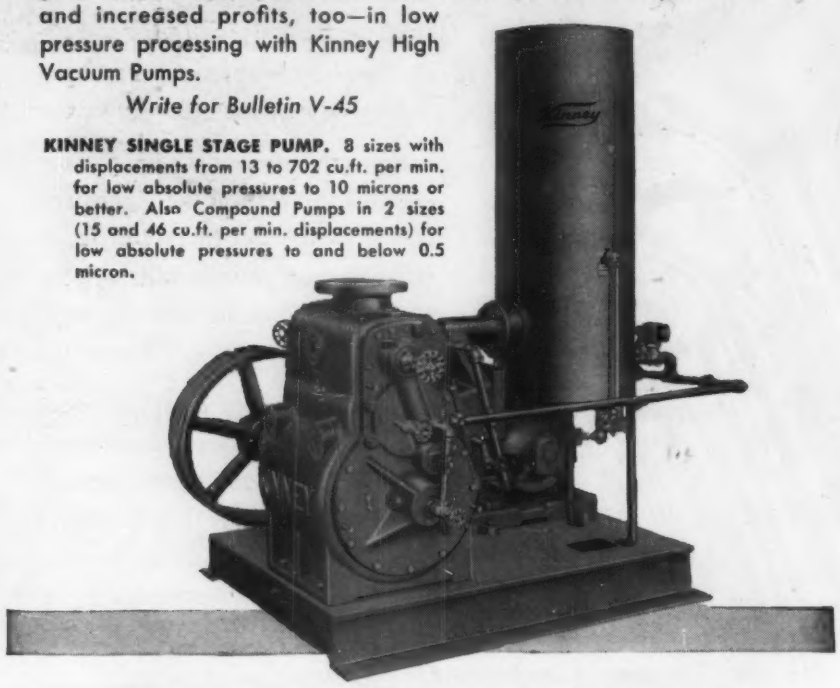

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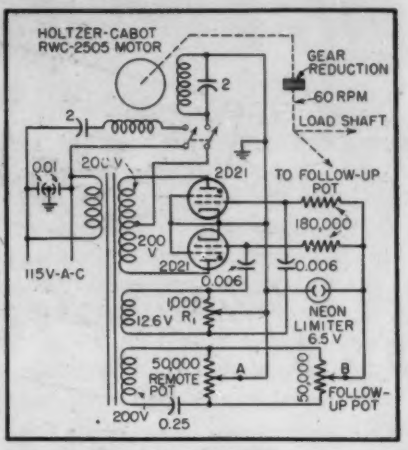

FIG. 1—Schematic diagram for remote tuning device using miniature thyratrons. Resistor R_1 is adjusted for no motor rotation with points *A* and *B* shorted

winding being connected in the mid-tap of the transformer secondary receives two 65-degree duration pulses for each cycle of a-c power. This is equivalent to a direct-current with a superimposed 120-cycle voltage. Since the other motor winding is excited from the line at 60 cycles, no rotation results.

If we now consider an unbalanced condition of the input bridge consisting of the two 50,000-ohm potentiometers, an error voltage in phase with the plate voltage will be impressed equally and in phase on both grids. The resulting grid voltage will cause one tube to increase its angle of plate current flow while the other will decrease.

The current passing through the motor winding now has a strong 60-cycle component and, depending on the phase relation of this component with respect to the fixed line excitation, the rotor will turn in one direction or the other. If the potentiometer bridge connected to the input is sufficiently unbalanced, it is possible for one tube to be completely cut off while the other is conducting over 180 degress.

The function of the 2-μf capacitor connected in parallel with one of the motor windings is to improve the 60-cycle power factor of the motor so that the output torque for moderate error voltages is increased while the volt-ampere load on the transformer is reduced. The 2-μf capacitor connected in series with the a-c line and the exciting winding produces 90-degree phase-shift for induction motor action.

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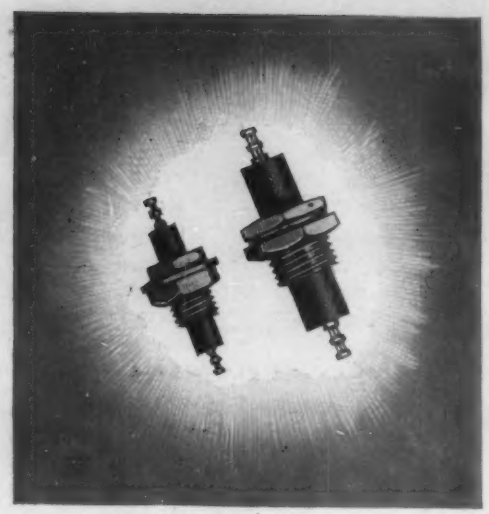

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The 1795B mounts in a ¼" hole, and has an over-all length of approximately ⅞". C.T.C. Feed-Thru Terminals are available in additional sizes. The 1795A is similar to the 1795B, but with an over-all length of 1". Also similar in design and function are X1771A and X1771B, but larger in size and mounting in a ⅜" hole. Breakdown voltages, at 60 cycles R.M.S., are:

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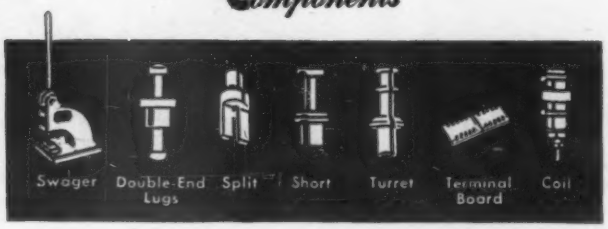

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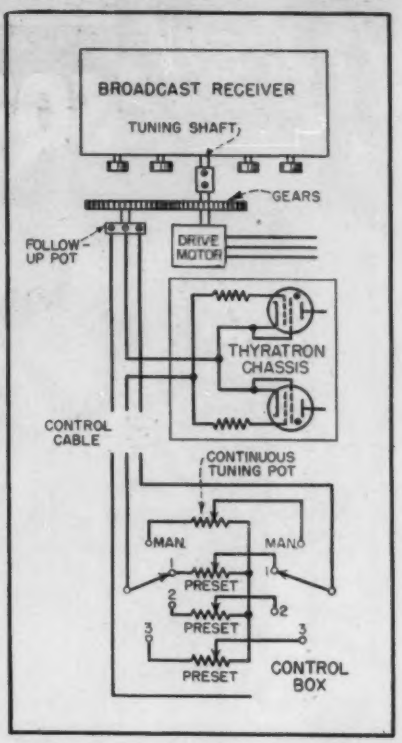

FIG. 2—The continuous tuning potentiometer is calibrated in frequency. The switching may be accomplished by a multi-position rotary switch or a bank of push-buttons

windings causes increased heating, it is nevertheless beneficial. The superposition of a continuous current converts the shape of the induction motor speed-torque curves so that the rotor speed is easily controllable by the stator voltage, and it provides a damping or anti-hunt torque proportional to the angular velocity of the rotor, thus preventing overshooting and the resulting continuous mechanical oscillation known as hunting.

The fixed a-c grid bias is made as low as possible without causing the grid to lose control, and the phase angle is made to approach 90 degrees. A single R-C network is used to supply this grid bias at a phase angle close to optimum value from the heater winding on the transformer.

Using a radio receiver with the servo-device incorporating a 15-watt Holtzer-Cabot gear head induction motor to drive the 4-gang tuning capacitor, the unit was capable of resetting to within 1,000 cycles at 1,000 kc.

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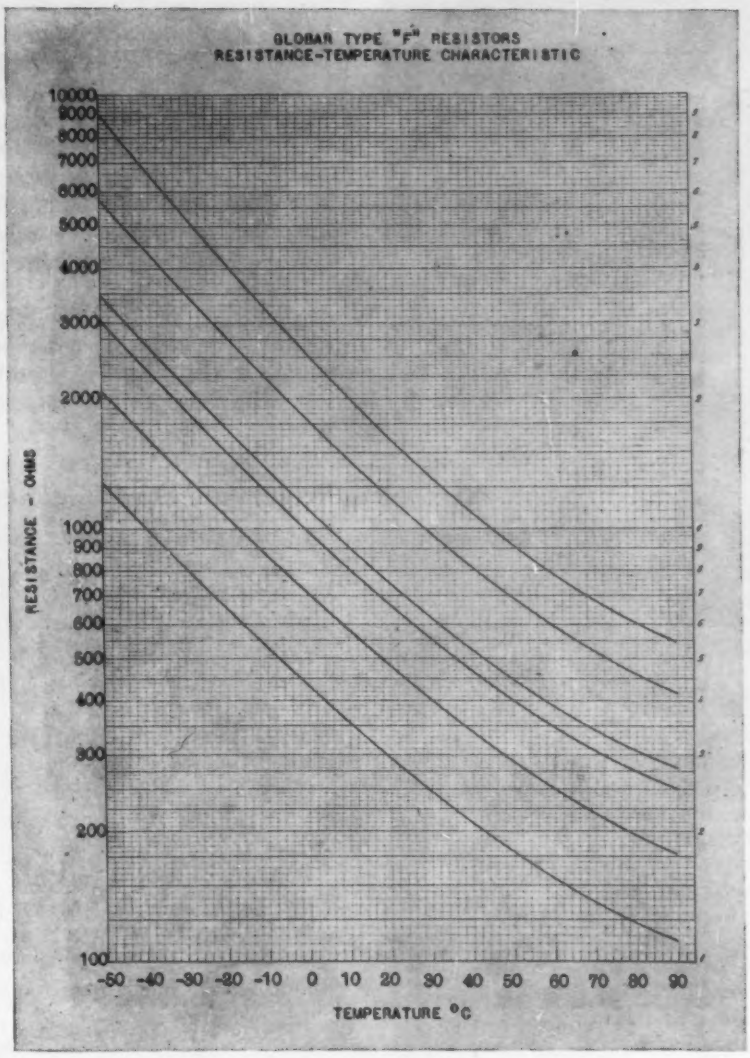

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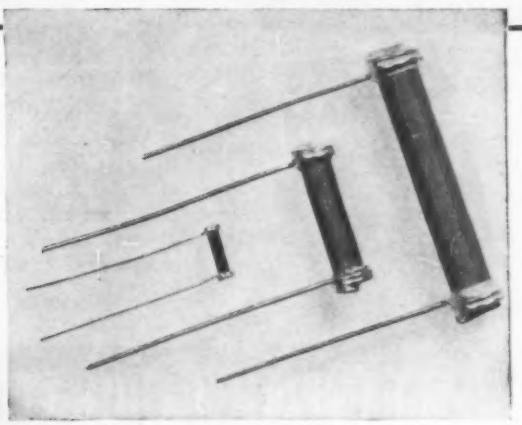

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BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

unit used for the continuous tuning function should be a wire-wound, high resolution potentiometer having at least 5 to 7 turns of wire per degree of rotation. Preset potentiometers are employed for rapid channel selection. In the circuit shown, one potentiometer per station is required.

The components contained in the control box consist of a number of preset potentiometers, a rotary switch or bank of push-buttons and a continuous tuning potentiometer which is calibrated in frequency. The circuit is shown in Fig. 2. In operation, one adjusts each potentiometer for each station. Thereafter, whenever the switch connects a particular potentiometer in the circuit, the gang capacitor in the radio receiver chassis is rotated to its correct position for station selection.

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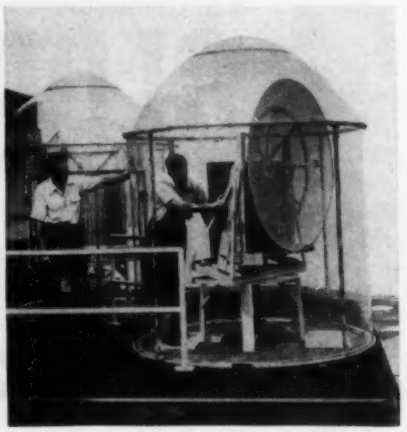

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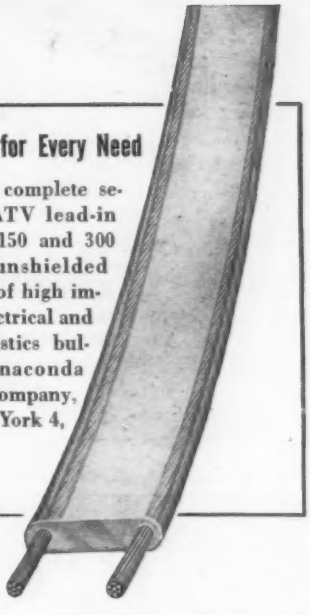

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FL-33 CRYSTAL PICKUP—Incomparable reproduction, utility and convenience. Employs LP-33 Crystal Cartridge for LP Records and LP-78 Crystal Cartridge for 78 RPM Records. Change cartridges in a second, like slipping modern fountain pen from its cap, nothing else to do. Special anti-resonance base mounting.

FLT-33 CRYSTAL TRANSCRIPTION PICKUP—Like the FL-33 Arm, plays either LP or 78 RPM Transcriptions with the LP-33 and LP-78 Cartridges. Anti-resonance base and arm-rest are adjustable to desired height. Five-gram needle pressure and perfect tracking assured by revolutionary hinged division of arm. Two-toned black and satin chrome finish.

FLT-TR CRYSTAL TRANSCRIPTION ARM—The same fine instrument as the FLT-33, except for 2.4 mill tip-radius needle necessary for lateral broadcast transcriptions. Employs the LP-TR Cartridge, instantly replaceable with LP-33 or LP-78 Cartridges."

510-QT-33 CRYSTAL PICKUP—Short mounting centers, gracefully curved lines and moderately offset head make this the ideal pickup for a host of applications. Famous "QT" Series Cartridge with replaceable, one mill tip-radius, precious metal or sapphire needle.

510-MI-2M-33 MAGNETO-INDUCTION PICKUP—Same as 510-QT-33, except for revolutionary Magneto-Induction Cartridge. Consistent service and adverse climatic conditions are no threat to the stability and troublefree operation of this magnetic type unit.

400-QT-33 CRYSTAL TRANSCRIPTION PICKUP—Graceful, slender-lined beauty of professional pickups. Employs QT Cartridge with replaceable precious metal or sapphire needle. Flawless reproduction at lower cost.

400-MI-2M-33 MAGNETO-INDUCTION TRANSCRIPTION PICKUP—Identical to 400-QT-33, except for Magneto-Induction Cartridge.

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tops are reinforced with an extra thickness of the acrylic at their crowns, where the ice might strike a direct blow. Except for this limited area, the curved shape of the structures guarantees that they will receive at worst a glancing blow.

First of their kind to be tested in actual use, these housings are made of shatter-resistant Plexiglas ½-inch thick. Plexiglas was chosen because it passed microwaves without perceptible distortion; it was easily formed to exact curvature and dimensions; although light in weight, it combined great shatter-resistance with inherent resiliency; it was virtually impervious to extremes of weather and continued exposure to sunlight; and finally, its transparency allowed quick inspection of the apparatus within, and simplified visual aiming of the antennas. Components are rubber-gasketed and assembled with stainless steel bolts.

A door in each structure gives access to the microwave equipment, which may be rotated and swiveled to permit accurate aiming at the point of program origin. To prevent development of excessive heat in the summer, or freezing condensation in cold weather, each housing has its own "air-conditioning" treatment. Forced air, which may be heated electrically in winter, enters through a floor register and is exhausted through hinged louvers in the side of the platform on which each antenna is mounted.

Servo Physical Tester

BASED ON PRINCIPLES used in wartime gun computers and rate setters, a servo-mechanical physical tester for plastics has been developed at MIT. It has a steel arm which pulls plastic test specimens with a force equal to that of an elevator car. This tremendous force is controlled automatically by mechanisms of featherweight sensitivity.

The tester, a product of the Society of The Plastics Industry's research program, was designed primarily for the observation of mechanical properties of plastics

achieving a new 'high' of efficiency!

U.I.C

CERAMIC *Hi-Load* CAPACITORS

Designs registered U.S.A., U.K. and other territories.

for R.F. Heaters and Transmitters

Special silver layer gives low-loss high conductivity electrode surfaces

Special ceramic body gives low losses under R.F. load

Tag electrode soldered to outside silver layer gives even current distribution

Glazed sheds give ample flash-over path in all conditions of humidity

Aero-dynamic shape gives improved cooling, particularly with forced draught

Heavy rod with double spider mounting gives reliable heavy current connection to inside silver layer

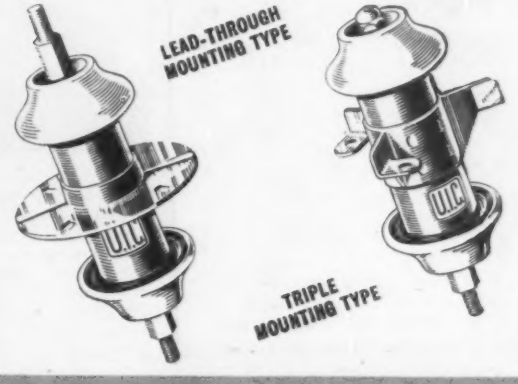
TAG MOUNTING TYPE

U.I.C. of England, pioneers in the manufacture of Ceramic Transmitter Capacitors, are foremost in the application of aerodynamic principles to capacitor design. The new aerodynamic shape of U.I.C. "Hi-Load" Capacitors gives optimum cooling in still air. With forced draught their high R.F. ratings can be multiplied. All three types of mounting assist cooling and cater for a variety of applications, such as single stand-off tag fitting, parallel and series banking for very large powers, and lead-through types for anode by-pass.

Examples from a wide range of Types

Type	HLS2031	HLT2021	HLT2021	HLC2011	HLC2014★
Capacitance	200mmF	330mmF	500mmF	1250mmF	1000mmF
Max. R.F. Load	70KVA	50KVA	50KVA	25KVA	40KVA
Peak Voltage	7.5KV	7.5KV	7.5KV	7.5KV	7.5KV
Max. R. F. Current	30 Amps	30 Amps	30 Amps	30 Amps	30 Amps
Body Dimensions	1¾" x 3½"	1¾" x 3½"	1¾" x 3½"	1¾" x 3½"	1¾" x 3½"

★ Lead-through type, all other examples tag type.



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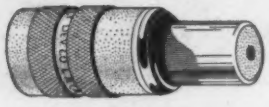

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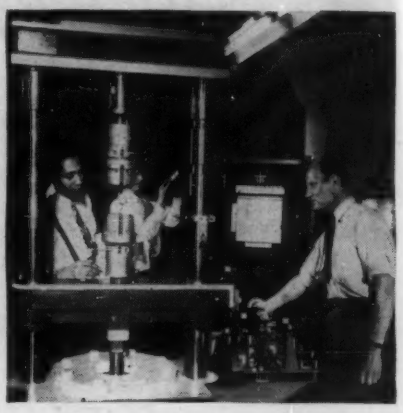

Servo-mechanical physical tester for plastic materials

and the molecular changes induced by. stress. Continuous recorders are a part of the equipment.

Airliner Television

ONE METHOD of obtaining good television reception from stations up to 180 miles away is being demonstrated to passengers aboard a nonstop DC-4 of Capital Airlines traveling between Washington and Chicago.

A standard home model Philco receiver with a twelve-inch tube is mounted on a small platform for viewing by all passengers. An amplifier and three extra loudspeakers provide sound for the rear seats. Dipole antennas are mounted on short masts, one under the belly of the plane and one on top of the fuselage behind the pilot's cabin. The antennas are connected to a small switch on the side of the receiver. The airline hostess chooses either the belly-mount or the fuselage-mount dipole, whichever gives best reception.

First run for the Television Express was on a Saturday in October, on a flight leaving Washington about noon. Passengers watched the entire fourth game of the World Series and part of the Notre Dame-Michigan State football game as the receiver was tuned to Cleveland, Toledo, Detroit and Chicago stations. On the return flight, passengers leaving Chicago at 6 p.m. saw programs from the same stations and also stations in Washington and Baltimore. The plane flew at about 10,000 feet, practically line-of-sight conditions.

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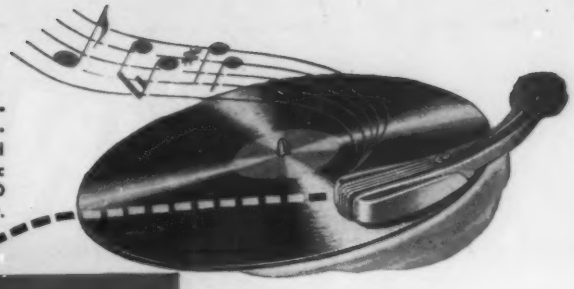

The G-E Electronic Reproducer, which magnetically recreates the full recorded sound, derives its magnetic field from a G-E SINTERED ALNICO 5 permanent magnet.

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Actual size of G-E SINTERED ALNICO 5 permanent magnet used in the G-E Electronic Reproducer is shown in red.

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SINTERED ALNICO 5, General Electric's newest magnetic material, now enables you to design intricate shapes with higher external energy than ever before. The minimum guaranteed available energy is 3,500,000 gauss oersteds for most sizes and shapes. New G-E SINTERED ALNICO 5 possesses tensile properties several times those of CAST ALNICO 5 and can be produced economically in small size parts. You get better surface finish plus closer dimensional tolerances with new G-E SINTERED ALNICO 5.

NEW DESIGNS POSSIBLE

New SINTERED ALNICO 5 has higher external energy than either SINTERED ALNICO 2 or 4. This makes possible new designs heretofore impossible or impractical. It is especially adaptable where small powerful magnets having high magnetic properties are required. Because of their great stability and external energy, SINTERED ALNICO 5 magnets can save valuable space in your product. You can usually improve your product by re-designing to use high energy G-E SINTERED ALNICO 5. Typical applications now in production which use G-E SINTERED ALNICO 5 include the following: meters, relays, fountain pens, electronic reproducers, and compasses.

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G-E application and development engineers, working closely together, are ready to advise you on new SINTERED ALNICO 5 and other G-E magnetic materials. Our engineers are backed by years of research and the development of thousands of magnetic applications. They will be glad to work with you on your product design. For more information, please mail the coupon shown below.

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(continued from p 126)

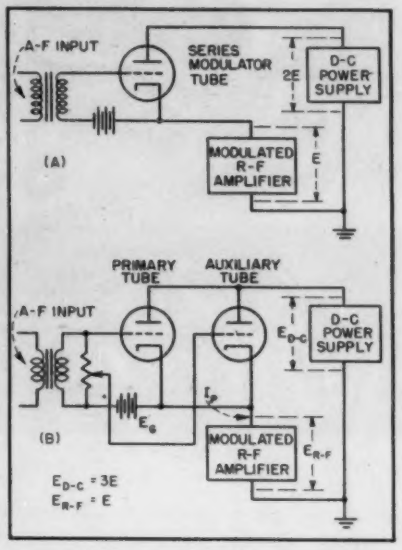


FIG. 1-(A) Conventional series modulator and (B) series modulator with auxiliary tube to suppress negative peaks

shows the basic circuit. The modulator operates like a class-A audio amplifier in that the grid never swings positive. In action, the modulator tube behaves as a variable resistance (with half the supply voltage across it when no audio signal is applied) in series with the modulated r-f amplifier. The variation in resistance acts at audio frequency, approaching zero resistance on positive peaks so that the full power supply voltage (twice the rated voltage of the r-f amplifier) appears across the modulated stage. On negative peaks, cutoff is approached (or reached) so that the tube impedance approaches (or reaches) infinite resistance.

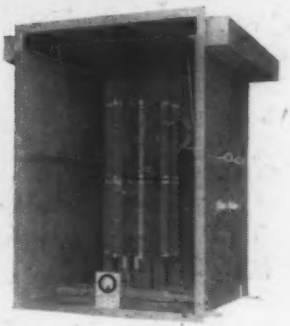
Modified Power Supplies

In practice it is found that, because the tube is not absolutely linear, it needs considerably more than half the power supply voltage across it in order to stay in the linear portion of its characteristic and still achieve 100-percent modulation on positive peaks without distortion. As much as 20 percent of the power supply voltage may still be across the modulator tube when 100-percent undistorted positive peaks are being handled by the modulated tube. (This remaining voltage could be considerably reduced by designing a tube for the purpose. The 6AS7G might prove very good in a low power modulator.)

By using several tubes in parallel,

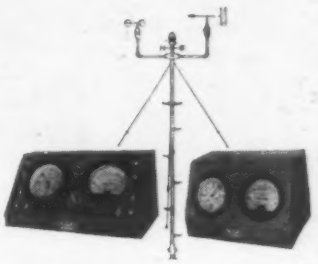
4 PROBLEMS 4 ANSWERS

You, as a Communications Engineer, will be interested in the four *Aerocom* products illustrated below. They are designed and built to solve your communications problem. They are the result of engineering knowledge and experience gained during 18 years of manufacturing communications equipment for more than 200 installations throughout the world.



WEATHERPROOF LOW FREQUENCY ANTENNA TUNER. Sturdily constructed; using heavy aluminum sheet and rustless hardware. Ample ventilation provided, yet insect and vermin proof. Suitable for 1-2 kw carrier, 200-415 kcs; coupling coil matches either coaxial or 2 wire line. Illustration shows cabinet with protective and weatherproof (no gaskets) covers removed. Locking facility provided.

AUTOMATIC KEYER provides continuous or interrupted identification signals for beacon or aerophare service. Small, compact (6-⅝" x 9" x 7") and fully enclosed, this keyer will give long trouble-free service. Two synchronized cams, which can be milled to your specifications, provide several keyer combinations. Motor -- 105/115 v-50/60 cy.



METEOROLOGICAL INSTRUMENTS -- Aerocom's group assemblies; anemometer and wind direction indicator on mast for outside installation, and reading instruments in cabinet or standard rack panel, give constant and reliable weather information. Instruments available: wind direction, wind speed, Kollsman station barometer (altimeter), 24 hour clock, or any combination thereof. Mast assembly may be remotely located from instruments.

LINE MATCH INDICATOR: Made in two models (a) LMI-72 for coaxial lines and frequencies from 0.2 to 10 mcs; (b) LMI-500 for balanced pair lines and frequencies from 0.2 to 2 mcs., or 2 to 20 mcs. These instruments permit adjustment of load for optimum line match. Sturdy and rugged, engineered for field use.

FOR OVER EIGHTEEN YEARS CONSULTANTS, DESIGNERS, AND MANUFACTURERS OF STANDARD OR SPECIAL ELECTRONIC, METEOROLOGICAL AND COMMUNICATIONS EQUIPMENT.

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These rings are now being used in special electric motors, calculators, and computators, Radar, and fire control instruments, potentiometers, and other electro mechanical devices.

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it is possible to make a slight change in the circuit that, with proper adjustment, will enable it to accentuate positive peaks and suppress negative peaks. In the circuit of Fig. 1B the grid of the auxiliary tube is shown connected to a tap across the audio input. Although there may be sufficient signal to cut off the primary tube on negative peaks, the auxiliary tube will still be conductive and hence the resistance of the modulator will not reach infinity and 100-percent modulation on the negative peaks is not attained. If in addition the static voltage drop across the modulator is increased from E to $2E$, it will be possible to furnish $3E$ to the modulated stage on positive peaks, or 200-percent modulation. Under this condition the tap for the auxiliary tube is adjusted so that its grid does not quite reach cutoff on negative peaks, thus 100-percent negative modulation will not be exceeded. Proper adjustment of the tap can be determined with an oscilloscope as shown in Fig. 2.

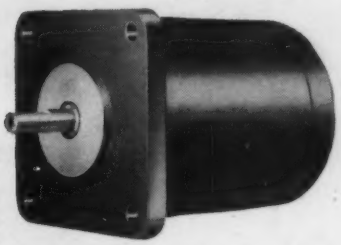
As is expected, the foregoing procedure introduces some distortion. However, for speech it is not objectionable at 150 percent modulation and does not interfere with the intelligibility at even 200-percent peak positive modulation.

Experimental Equipment

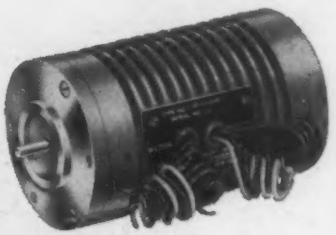
To demonstrate the feasibility of the method, a transmitter using type 10 tubes and having series modulation was modified for the purpose. With conventional 100-percent modulation, 400 volts appeared across the r-f stage and about 600 across the modulator. On 200-percent modulation with suppressed negative peak, about 250 volts appeared across the r-f stage and 750 across the modulator. The ideal values for these respective conditions would be 500–500 and 333–667.

More detailed data were obtained from a transmitter having a single-ended 304TL r-f stage and 304TL's in the modulator. Transformer coupling into the modulator tubes was found necessary to provide a low-impedance d-c grid return. Although a power supply capable of providing nine times the unmodulated carrier power on positive

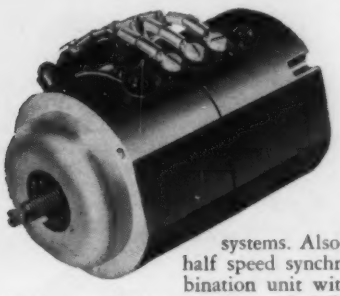
Kollsman offers additional AC units for remote indication or control applications



SYNCHRONOUS MOTORS—for timing applications where variable loads stay in exact synchronism with constant or variable frequency source. Synchronous power output up to 1/100 H.P.

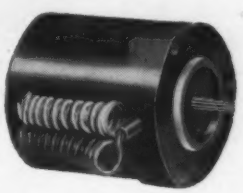


MOTOR DRIVEN INDUCTION GENERATORS — combination of a 2-phase, high-torque, low-inertia induction motor and an induction generator. Used as a fast reversing servo motor. Available with maximum stall torques of 1.0 (unit shown) to 6.7 (other units) oz/in.

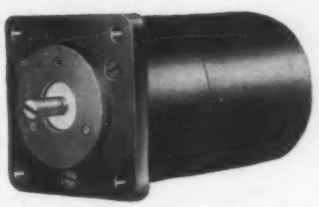


SYNCHRONOUS DIFFERENTIAL UNITS—electro-mechanical error detector with mechanical output for use in position or speed control servo systems. Also a torque-producing half speed synchroscope. Small combination unit with two variable frequency synchronous motors and differential gearing. Output: Speed $= \frac{N_1 - N_2}{2}$; torque up to 1.0 oz/in.

TELETORQUE UNITS—precision built selsyn type units for remote indication. Accurate to ±1 degree. Actuated by units producing as little as 4 gr/cm of torque.



DRAG CUP MOTORS—miniature 2-phase motors with high torque/inertia ratio and extremely fast stopping, starting and reversal characteristics. Suitable for many special applications requiring torque of 0.4 oz/in. or less.



GEARED INDUCTION MOTORS—miniature 2-phase servo motors with gear reducer. Desirable motor features: Maximum torque at stall with low wattage input and high torque/inertia ratio. Gear reducer conservatively rated at 25 oz/in. Maximum torque with gear ratios from 5:1 to 75,000:1 available.

Because of their high responsiveness and precision, Kollsman Special Purpose Motors are particularly suited to systems requiring extremely accurate remote indication or positive electronic control. The units shown above are only representative of a complete line which includes many similar units in various voltages and frequencies. Among them, the instrumentation or control engineer will find, in many instances, the device that fills his specifications exactly.

Reliable performance, light weight and compact size are characteristics of the entire line. In each unit is to be found the same ingenuity of design and care in manufacture that has for twenty years made Kollsman the outstanding leader in the field of aircraft instrumentation.

For full information on any or all of these Special Purpose Motors, write to: Kollsman Instrument Division, Square D Company, 80-64 45th Avenue, Elmhurst, N. Y.

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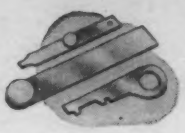
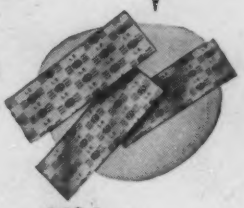


and thermometal

contact assemblies



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SECOND . . . the facilities of THE H. A. WILSON COMPANY permit you to secure both electrical contacts and thermostatic bimetal from a single source for use as parts of the same device . . . *contact assemblies* designed and manufactured *under one roof* . . . combining the superfine quality of WILCO contact materials and WILCO thermometal to meet the highest performance standards.

THIRD . . . you obtain the cooperation of the WILCO Sales and Engineering Departments . . . who are thoroughly familiar with both electrical contact and thermometal application . . . and thoroughly equipped to help you achieve your objectives of reduced costs, improved performance or new product development. Whatever your requirements for contacts or contact assemblies, WILCO engineers will gladly help you meet them successfully.

WILCO PRODUCTS INCLUDE: THERMOSTATIC BIMETALS: All temperature ranges, deflection rates and electrical resistivities. ELECTRICAL CONTACTS: Silver, Platinum, Tungsten, Alloys, Sintered Powdered Metal. SILVER CLAD STEEL: For industrial use. NI-SPAN C* Constant Modulus Alloy; also low and high expanding Ni-Span Alloys. JACKETED WIRE: Silver on Steel, Copper, Invar and many other combinations. SPECIAL ALLOYS: Including high conductivity, high strength, Copper Alloys. ROLLED GOLD PLATE AND GOLD FILLED WIRE.

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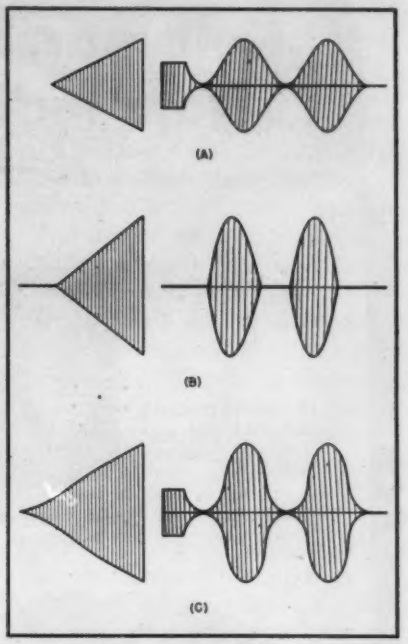


FIG. 2-(A) Conventional 100-percent modulation, (B) unsuppressed 200-percent modulation, and (C) 200-percent modulation with auxiliary tube adjusted to limit negative peaks

peaks may seem excessive, the fact that this power need be provided only on such peaks means that, in practice, the filter capacitors can be relied upon to supply the peaks; the power transformer and filter chokes need be but little larger than for a conventional modulator. The heavier the modulation, the smaller the power dissipated in the modulator tubes. Thus considerable increase in peak power is made possible with negligible increase in power supply. In addition, because series modulation is used, a heavy modulation transformer and speech amplifiers are omitted; a voltage amplifier is

MODULATOR CHARACTERISTICS

Percent Positive Peaks	E_{R-F} Volts	E_{D-C} Volts	I_F Ma	E_G Volts
TWO TUBES				
100	1,050	2,700	370	—120
125	850	2,750	300	—130
150	750	2,750	270	—145
200	650	2,800	240	—165
THREE TUBES				
100	1,100	2,600	380	—117
125	900	2,700	330	—130
150	800	2,800	270	—150
200	700	2,750	240	—165

Percent negative peak modulation: 100

This new automatic voltage stabilizer supplies a constant 115 volts

We want to get in touch with any manufacturer whose product will operate better if supplied from a stabilized voltage source.

General Electric has recently announced three new automatic voltage stabilizers that provide steady, dependable output voltages, despite varying input voltages. Rated 15, 25, and 50 volt-amperes, these stabilizers are instantaneous (recovery time: 3 cycles), entirely automatic, and have no moving parts. They deliver 115 volts output (± one per cent for fixed, unity power factor loads) with the input voltage varying from 95 to 130 volts.

These units will operate continuously at no load or short circuit without damage to themselves. They will limit the short circuit current to approximately twice normal full load current. Dimensions are $9\frac{1}{2} \times 3\frac{1}{8} \times 2\frac{11}{32}$" high—making possible shallow depth installations. Other standard G-E stabilizers are available in ratings from 100 to 5000 va.

Drop us a line if you see a possibility for these new automatic voltage stabilizers in your product. Please give us all the information you can—and if possible, a circuit diagram or description of the load, so that we can help you in evaluating the application. Simply address your nearest G-E Apparatus Sales Office or *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

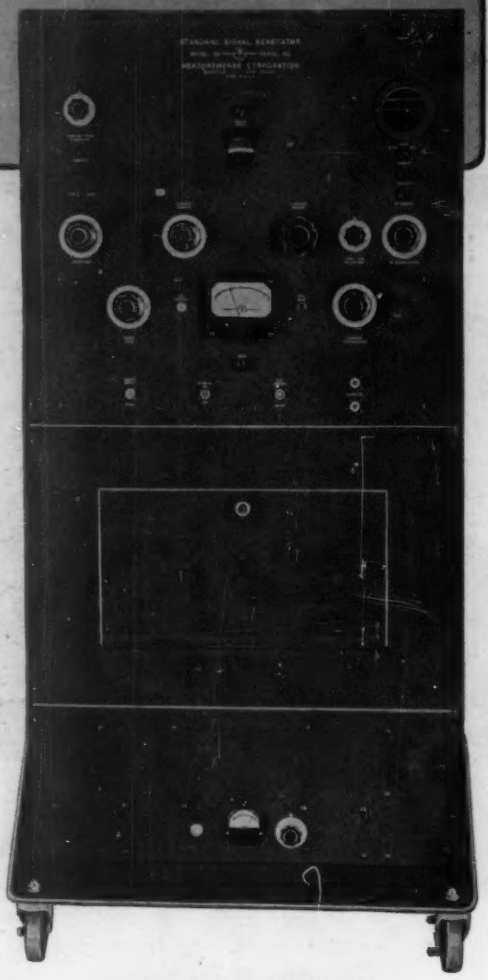
GENERAL ELECTRIC

411-34

MEASUREMENTS CORPORATION

TELEVISION STANDARD SIGNAL GENERATOR

MODEL 90



SPECIFICATIONS:

● **CARRIER FREQUENCY**

RANGE: Continuously variable from 20 to 250 megacycles, in eight ranges.

ACCURACY: Crystal frequency standard permits setting to .01%. Dial scale may be set to 0.1%.

STABILITY: Warm-up drift less than .05%.

LEAKAGE: Less than 10 microvolts.

● **MODULATION**

Continuously variable from zero to 100%.

ENVELOPE: Sinusoidal, or composite television. Bandwidth to 3 db is 4 Mc. Rise time from 10% to 90% modulation 0.15 microsecond. Overshoot less than 5%. Slope less than 5% on 60 cycle square wave.

INPUT IMPEDANCE: 75 ohms ± 10% (RMA Standard).

INPUT LEVEL: 1.5 volts peak to peak minimum level for 100% modulation. Black negative polarity.

MODULATION PERCENTAGE: Zero to 110%; plate modulation.

● **OUTPUT**

LEVEL: Continuously variable from 0.3 microvolt to 0.1 volt balanced to ground (measured at 100% modulation level).

IMPEDANCE: (a) 107 ohms line to line (balanced).
(b) 53.5 ohms line to ground (unbalanced).
(c) Suitable pads may be employed to alter these impedances.

● **DIMENSIONS**

OVERALL: Height—58¾"; Width—28¼"; Depth—25½".

WEIGHT: Model 90—302 pounds. External Voltage Regulator 92 pounds.

POWER SUPPLY: 117 volts, 60 cycles.

THE FIRST COMMERCIAL WIDE-BAND, WIDE-RANGE SIGNAL GENERATOR EVER TO BE DEVELOPED

The Model 90 employs a master oscillator, buffer amplifier and modulated power amplifier. The push-pull buffer eliminates incidental frequency modulation.

Features: A self-contained crystal calibrator and individually calibrated dial scales permit frequency settings to a high degree of accuracy. A built-in video modulator with manual or automatic dc inserter, designed to operate from a standard RMA composite signal. Continuous monitoring is provided by built-in oscilloscope.

This signal generator meets the most exacting standards required for high definition television use.

ADDITIONAL DATA ON REQUEST

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Pulse Generators
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Phase Sequence Indicators
Television and FM Test Equipment

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sufficient to drive the modulator. The modulator is as shown in Fig. 2A. The accompanying tabulation gives data taken with it for two conditions: (1) two 304TL's in parallel, one having reduced audio excitation, and (2) three 304TL's in parallel, again with one having reduced excitation.

Although this method of suppressing the negative peak so that amplitude modulation in excess of 100 percent can be obtained without sideband splatter may not be desirable for high-power transmitters, it is economical for some uses of low-power transmitters. For example, using this method, the watt-hours at the increased voltage, with appropriate batteries, obtainable from such portable equipment as that used by the forestry fire wardens can be increased without increasing the weight of the equipment.

Transitron Oscillator Tube

A SPECIALLY-DESIGNED TETRODE or a standard pentode can be operated with the second grid acting as the anode of an oscillator and the plate acting as an electron reflector; the potential of the reflector controls the transit time and hence the frequency of oscillation, as described by Jerome Kurshan in a paper entitled The Transitron, An Experimental A.F.C. Tube, presented before the National Electronics Conference in November and published in the *RCA Review* for December.

Used as the local oscillator in an f-m receiver (88–108 mc) with automatic-frequency control, an experimental tube showed a sensitivity of 100 kc per volt, thus counteracting warmup drift at the high-frequency end of the band by a factor of 4.5. Tests of commercial miniature tubes in the accompanying circuit showed that the 6BE6 with its third (r-f signal) grid as reflector and biased to at least 20 volts negative was one of the strongest oscillators. The 9001 gave the greatest control sensitivity, but oscillated very weakly; the 6AK5 performed most reliably but had low control sensitivity. A special Transitrol tube was built

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● You can cut your fine-wire coil production time very substantially because Belden Celenamel* has eliminated the need for a stripping operation.

You save money, too, because you eliminate the greatest cause of rejections.

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It is unnecessary to remove the Celenamel* insulation, in soldering operations. Simply dip the leads in a lead-tin bath at 600F to 700F or apply soldering iron directly.

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Celenamel* magnet wire—a copper wire insulated with a film of cellulose acetate combined under heat with other resinous materials. The film so produced is tough, flexible, continuous, and of high dielectric strength. The insulation additions produced with Celenamel* have close and uniform tolerances.

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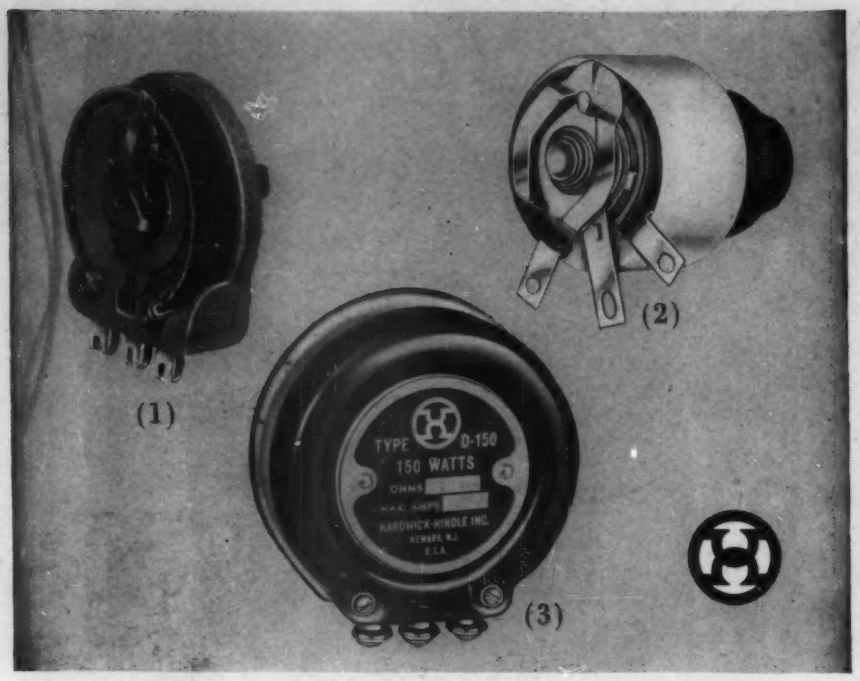

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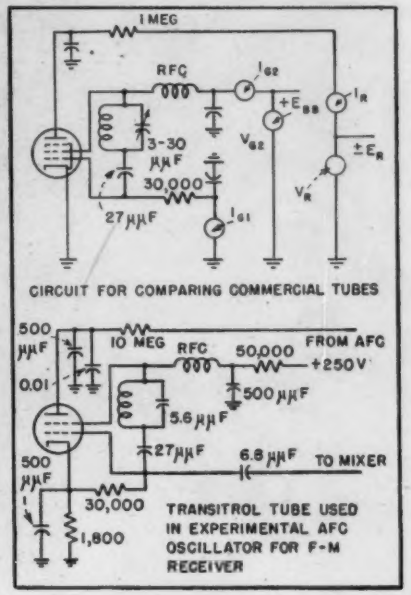
and tested in the circuit shown in the diagram; its performance correlated well with theoretical expectations.

Transit-Time Frequency Control

Because of the greater need for afc in the vhf region (30–300 mc) than in the lower-frequency bands, a simple means of controlling the frequency of a local oscillator is



To determine the suitability of commercial tubes for Transitrol operation they are tested in the top circuit. The voltage applied to the second grid should be large enough to produce stable oscillation but not so large as to exceed the grid dissipation. The reflector voltage is adjusted for zero reflector current. The bottom circuit shows the oscillator using a modified 6BE6 which reduced warmup drift by a factor of 4.5 from that without afc

needed. Although a reactance modulator can be used, it entails an additional tube in the receiver.

The pulling of the local oscillator frequency by changes in the bias on the r-f signal grid, an effect sometimes observed in converters, can be used as the basis for afc. The frequency pulling arises because, as the bias changes, electrons are variously reflected back to the oscillator section where they interact with the electrodes and space charge to produce a changing susceptance across the oscillator circuit. To make use of the effect, the tube is so operated that electrons leave the cathode, pass through the control grid, are accelerated by the screen, are possibly

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reflected by the reflector, and finally reach the anode. By changing the potential on the reflector, the transit time of the electrons between grid and anode can be altered. By deriving a direct voltage from the discriminator of an f-m receiver and using it to control the reflector, afc is obtained without an additional tube.

Operation

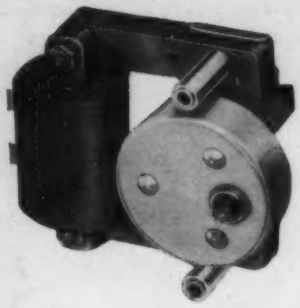
An analysis of the oscillator shows that a small capacitance in its resonant circuit is desirable for control sensitivity, although then there will be considerable warmup drift because interelectrode capacitance is a large fraction of the resonant-circuit capacitance.

In practice, it is desirable to keep the voltages on the anode and the control potentials small for large control sensitivity. The reflector spacing in the experimental tube was adjusted to obtain the optimum response with these conditions, but some commercial tubes have such spacings that, by suitable choice of their electrodes and potentials, they can be used with reasonable sensitivities, such as the 6BE6 previously mentioned.

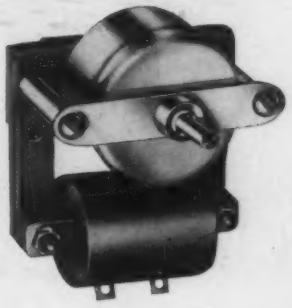
Circuit for Testing Tubes

The Colpitts oscillator circuit shown in the diagram was used to test commercial tubes in this afc circuit. For f-m receivers with a standard i-f of 10.7 mc, the local oscillator normally ranges from 99 to 119 mc. Miniature tubes are most suitable for this range. Also, the Colpitts circuit, using the interelectrode capacitances for feedback and with the cathode grounded, is the simplest to use at these frequencies. For transit-time control, it is important that the cathode be at ground potential.

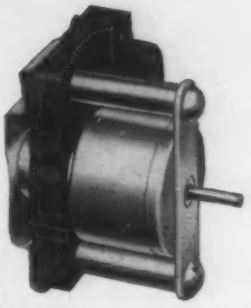
Unfortunately, neither end of the tuned circuit is at ground. It is necessary for this application that there be an r-f field between the second grid and the reflector, otherwise the transit of the electrons would effectively terminate when they passed the second grid (anode), because thenceforth they could not induce voltage in the resonant circuit. Practically, it is simplest to have the reflector at r-f



Light-duty motor, type H3. Torque rating .018 pound-inch at 3.6 rpm. at 60 cycles.



Medium-duty motor, type H5. Torque rating from .20 pound-inch at 6 rph. to .50 pound-inch at 1 or 2 rph. at 60 cycles.



Medium-duty motor, type B. Torque rating of various models from .015 pound-inch at 60 rpm. at 60 cycles to .375 pound-inch at 1 rpm.

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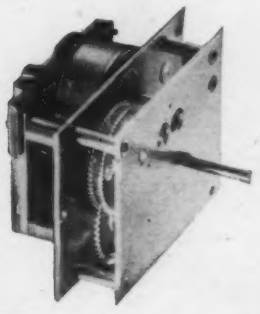
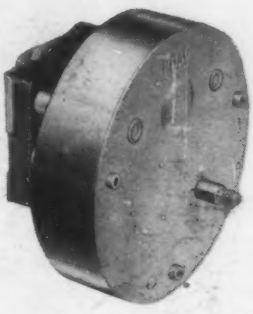


Type 1M8 synchronous movement. Small, compact movement for light-duty applications. Terminal shaft speeds from 12 rph. to one revolution in 24 hours. Terminal shaft rotation clockwise.



Type 1M9 instrument movement. Designed especially for chart drives but adaptable to most instruments. Terminal shaft speeds from one revolution in 15 minutes to 1 in 30 days. Terminal shaft rotation counterclockwise.

Count on a Telechron synchronous electric motor for the absolute accuracy and dependability so vital in automatic timing, switching, control and recording instruments. These self-starting motors are engineered and precision-built for long, continuous service in an almost limitless range of industrial applications.

Because they operate in perfect synchronism with any commercial frequency, *they have to be accurate* . . . can't run faster or slower. The replaceable, high-speed rotor unit is *sealed in* to keep out dust, and lubricated by Telechron's exclusive oiling system for long life. Fields are mounted externally for easy service and lower operating temperatures.

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These motors give you the advantages of the longest engineering and manufacturing experience in the field. They're built by the largest producer of synchronous electric timing motors for over 25 years. Every one is Underwriters Laboratories approved. Telechron *application engineers* are always glad to discuss your special requirements. Address Motor Advisory Service, Dept. M, Telechron Inc., Ashland, Massachusetts.

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ground, which requires that the cathode also be at r-f ground to avoid reflector current due to electrons that would be emitted at the negative peaks of cathode voltage.

SURVEY OF NEW TECHNIQUES

MINIATURIZATION of airborne equipment is now being carried on by the Air Materiel Command at Wright Field, Patterson, Ohio with the objective of reducing electronic gear to 20 percent of its present size, but without impairing performance. By redesigning tubes to subminiature size, the same characteristics are being obtained in 80-percent less space for amplifiers, 90-percent less space for rectifiers. The size and weight of transformers has been reduced to a third their present values.

In addition to these and other reductions in sizes of components, the compactness of the assembled equipment contributes to the reduction in overall bulk.

Printed radio circuit techniques are used to minimize the sizes of low-level circuits; cooling, using liquid Freon, enables parts in high-level circuits to be grouped more compactly and at the same time protects the equipment from atmospheric effects (fungus and oxidation) and reduces the possibility of burnouts so that the equipment will outlast conventional gear. The need for more electronic equipment in modern high-speed aircraft and the reduced space for such equipment makes this miniaturization necessary for expanded applications of electronics in aviation.

A NEW HEARING AID A-BATTERY extends the life of such subminiature batteries to 80 hours (4.25 ampere-hours under ASA test). Hearing aid A-batteries using two pen-sized flashlight cells gave 8 hours service and have been improved so that they give 24 hours service. Although the new National Carbon Co. unit is the size of these dual pen-cell batteries (A on accompanying graph) used in single-unit hearing aids, it has the life of the larger cell (see B on graph) which are used in old-style hearing aids having

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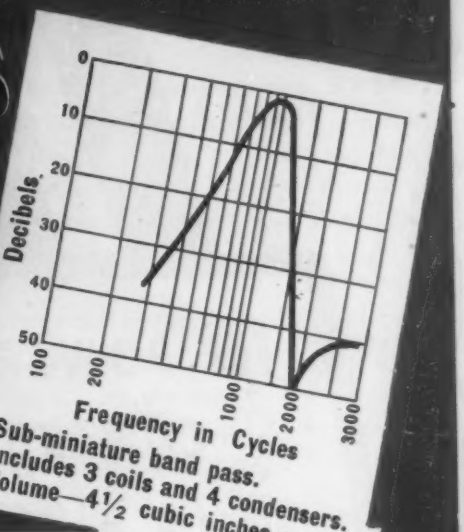
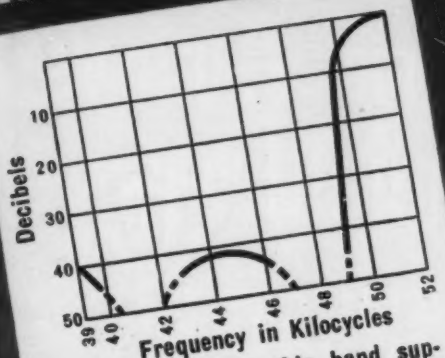
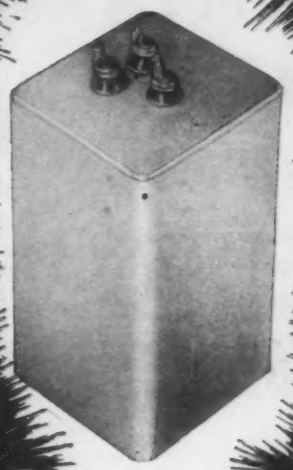
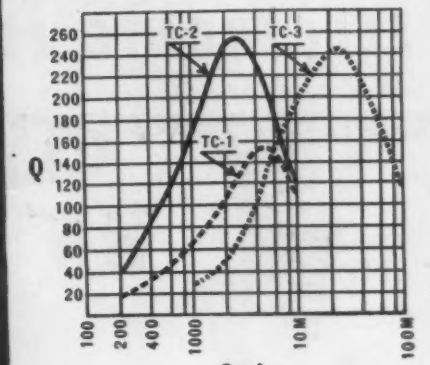


Sub-miniature band pass.
Includes 3 coils and 4 condensers.
Volume—4½ cubic inches.

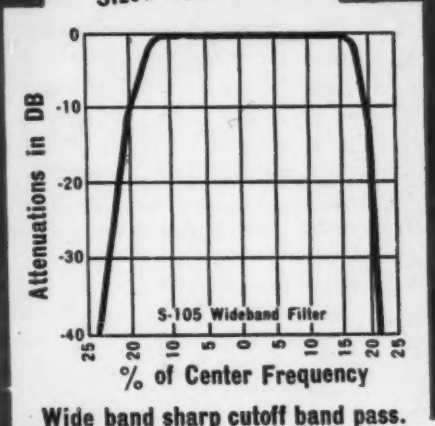


Extremely sharp side band suppression filter. Available in either low or high pass.
Size: 2½ x 4 x 2½.

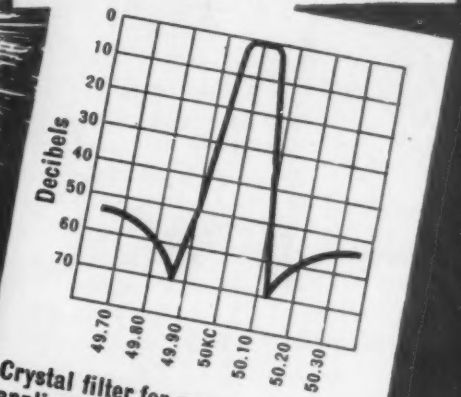




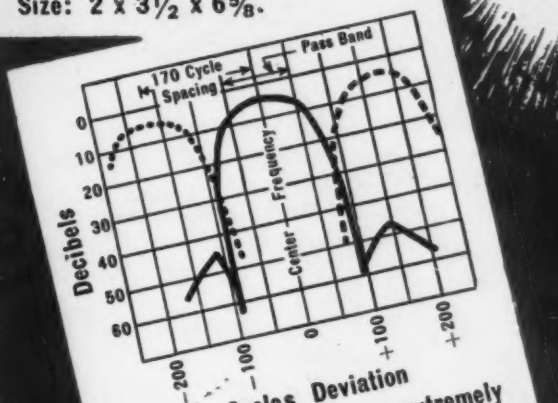
The big three out of 30 types of toroidal coils we are supplying.
TC-1 any ind. up to 10 hys.
TC-2 any ind. up to 30 hys.
TC-3 any ind. up to .750 hys.



Wide band sharp cutoff band pass.
Size: 2 x 3½ x 6⅝.



Crystal filter for narrow band pass applications too critical even for toroidal coils.



Tone channel filter for extremely high crossover attenuation requirement. Size: 2½ x 2½ x 5.

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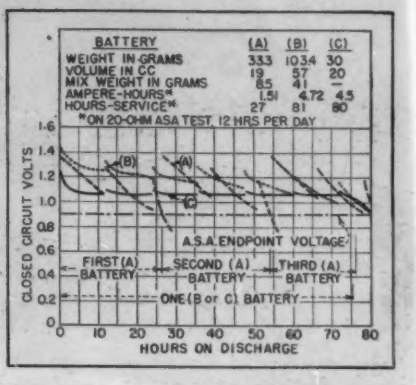


Comparison of two A-batteries commonly used in hearing aids (A) and (B) with new cell (C)

separate battery packs. The new cell (C) uses oxygen from the air as its depolarizer, thus enabling the chemical content to be devoted to electrolyte, giving larger power output per weight and volume than do other batteries. It consists of (1) two oxygen-absorbing carbon strips (positive electrode) bonded to (2) a perforated metal strip and molded into (3) a plastic case having air vents and into which is poured (4) a gel-paste that immobilizes (5) the alkaline electrolyte in the center of which is inserted (6) a sheet of zinc (negative electrode) that will be completely consumed at the end of the cell's life. The action of these six parts of the battery is effectively the burning of the zinc electrode in the oxygen of the air. The vents in the plastic case are sealed with a vinyl tape until the battery is placed in operation so that the shelf life of the sealed cell is very long. It is rated for use at 20 to 80 ma (ampere-hour capacity is little affected by the rate of drain within these limits.) Terminal voltage into a 20-ohm load is practically constant (75 percent of life) at about 1.06 volts.

A PLASTIC BASE for printed circuits is being used by Telex, Inc., Minneapolis, manufacturer of hearing aids. The chief advantages in using plastic bases are lightness, flexibility, durability, and moisture resistance. Conductors and resistors are etched into the surface of the plastic by the silk-screen process and then the circuit is hermetically sealed. The new printed circuit used a 0.025 inch thick piece of polystyrene (Styron) which

Here's on-the-job proof of instrument performance!

largest hydroelectric development in the world . . . employs WESTINGHOUSE INSTRUMENTS

The *Coordinated Design and Styling* of Westinghouse instruments contribute greatly to the space-saving arrangement and excellent appearance of this installation.

For such complex and exacting instrument applications, *reliability* is a "must". Every part of Westinghouse instruments is completely designed and manufactured by Westinghouse to insure proper relation with all other parts. This undivided responsibility and attention to all details assures you of unfailing performance.

What are YOUR electrical measuring problems?

Would they include—reliable performance . . . styling . . . size . . . readability . . . or different types of service . . . portable . . . switchboard . . . panel . . . recording?

The vast lines of Westinghouse electrical measuring instruments provide you with the answers to all of these problems. Every Westinghouse instrument is backed up by more than 60 years of skill, "know-how", and experience in every field of industry.

Westinghouse Instruments Also Provide You With

- Dials that *stay* white under all conditions.
- Springs that remain constant for life.
- Magnets that stay permanent.
- Quick delivery of more different ratings and types.
- Pivots with high shock capacity and low friction.
- Complete Nationwide Service.

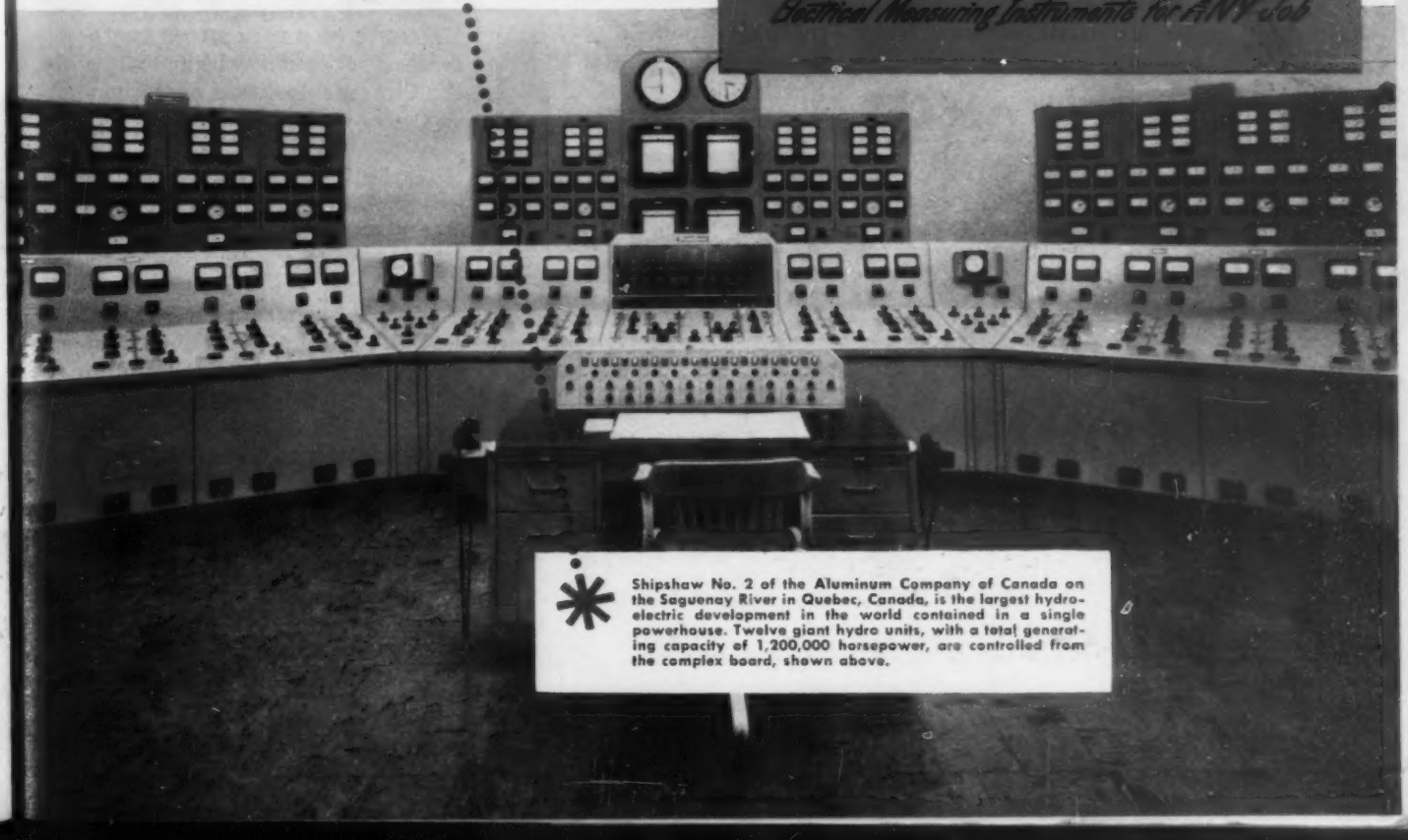
J-40363

Westinghouse instrument specialists are available in the field for consultation on your instrument problems. Call your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

Send for booklet B-2209-A, Communication Instrument Booklet B-3283, or Switchboard Instrument Booklet B-3363.

YOU CAN BE SURE . . . IF IT'S Westinghouse

Electrical Measuring Instruments for ANY Job



* Shipshaw No. 2 of the Aluminum Company of Canada on the Saguenay River in Quebec, Canada, is the largest hydroelectric development in the world contained in a single powerhouse. Twelve giant hydro units, with a total generating capacity of 1,200,000 horsepower, are controlled from the complex board, shown above.

PAMARCO WIRE DE-REELING TENSIONS

PROOF OF PERFORMANCE!

*. . . IN THE NEW YORK TRANSFORMER CO., INC. WINDING DEPT., PAMARCO DE-REELING TENSIONS REDUCE WINDING COSTS AND REJECTS**

PAMARCO tensions are the low-cost answer to lower coil winding costs. The free-running action of the PAMARCO tension practically eliminates wire breakage, shorted turns, allows higher winding speeds. Their compact size permits many more simultaneous coil winds on *any* machine. Simple thumb screw adjustment makes it possible for the operator to rapidly adjust for any gauge wire . . . no tools or special skill are required.

*The economies effected with PAMARCO tensions are a proven fact in hundreds of installations. For detailed information call or write today without obligation.

PAPER MACHINERY & RESEARCH, INC.
1014 OAK STREET • ROSELLE • NEW JERSEY

measures 1 11/16 inches in length by 1 5/16 inches wide. The one-piece Telex "99" hearing aid circuit using this polystyrene base weighs 5 ounces including batteries, while the plastic base itself weighs only 1/32 of an ounce.

RADIATIONS similar to cosmic rays will be generated by the 1,000,000,000 electron-volt accelerator to be completed in 1951 at Stanford University, Calif. The prototype electron accelerator (ELECTRONICS, p 144, Nov. 1947) was 12 feet long and produced 6 mev. The full-scale wave guide accelerator, being developed under direction of Dr. W. W. Hansen, will be 160 feet long.

SENSITIVITY of the zeus ionization chamber circuit can be increased by using a new subminiature tube having a maximum grid current rating of 2×10^{-13} amperes. The tube's filament, rated at 1.25 volts and 10 ma, is designed for operation directly from a dry cell. The new CK571AX tube has a slightly higher mutual conductance and gain than the CK5697/CK570AX, which was originally designed for the zeus circuit (see ELECTRONICS, p 182, Nov. 1947 and p 196, Jan. 1948), and can therefore be used in this circuit. This new Raytheon tube can be employed in various portable instruments for measuring radioactivity.

MAGNETIC POLE FACE SHIMS for the synchrocyclotron now being built by the Carnegie Institute of Technology are radically different from conventional design. In addition to the series of steps usually machined into the profiles of pole tips, deep concentric grooves are being milled near their edges. As a result, the new design extends the useful radius of the magnet to 96.5 percent of the actual shim radius (compared to 85 to 90 percent heretofore possible). In this way the 150-ton cyclotron will be able to produce 400-mev particles with only 160-ton pole pieces having 141.65-inch, 30-ton shims. (Existing machines in the same energy class require from 2,000 to 4,000 tons of steel.) The design constituted the thesis of M. H. Foss, for which he was awarded his doctorate last June.

for TELEVISION'S exacting applications

Designed for dependable operation up to 450 volts at 85°C. these new Sprague electrolytics are a good match for television's severest capacitor assignments. An extremely high stability characteristic is assured, even after extended shelf life, thanks to a special Sprague processing technique. Greatly increased manufacturing facilities are now available.

Your inquiries concerning these new units are invited.

DEPENDABILITY
TO MATCH THESE
NEW ELECTROLYTICS!
SPRAGUE PHENOLIC
MOLDED TUBULARS...
Highly heat- and moisture-resistant—Non-inflammable—Moderately priced—Conservatively rated for —40°C. to +85°C. operation—Small in size—Completely insulated—Mechanically rugged—Thoroughly field-tested
Write for Engineering Bulletin 210A

SPRAGUE ELECTRIC COMPANY · NORTH ADAMS, MASS.

SPRAGUE Capacitors * Koolohm Resistors

PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS

*T. M. Reg. U. S. Pat. Off.

You can stand pat with windings by COTO-COIL. There is no gamble because there's nothing that can beat them.

We place our 31 years of experience at your service, plus unexcelled facilities for producing the coils you're looking for.

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To Quote On

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ACETATE INTERLEAVE • COTTON INTERWEAVE
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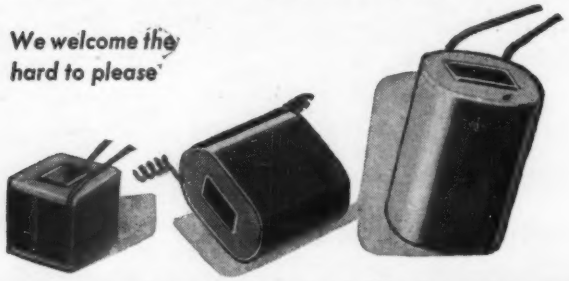
UNIVERSAL SINGLE OR MULTI-PIE CROSS WOUND

We welcome the hard to please



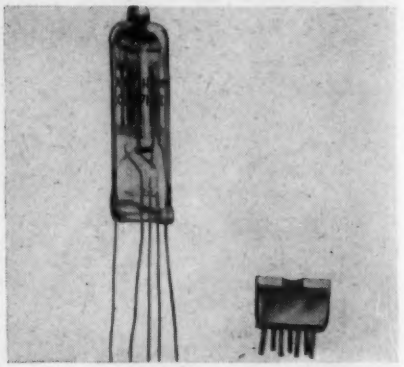
COTO-COIL CO., INC.
COIL SPECIALISTS SINCE 1917
65 Pavilion Ave., Providence 5, R. I.

(continued from p 130)

seconds per point. In case of trouble thermocouples can be cut out in banks of 20 at a time. When a temperature reaches a preset limit an alarm sounds.

Subminiature Tube

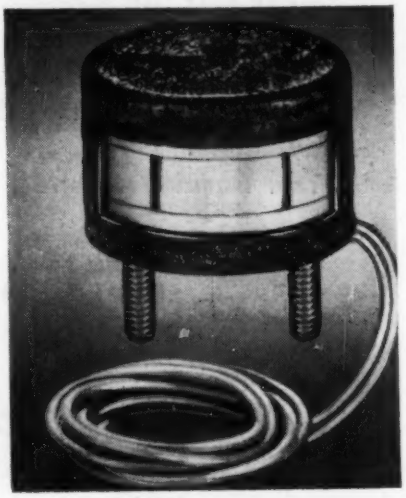
RAYTHEON MFG. CO., Newton, Mass., has added type CK571AX electrometer tube to its subminiature line. The filament is designed to be operated directly from an ordinary battery cell and draws 10 ma at nominal rating of 1.25 volts.



Besides its applications in the 2-tube zeus circuit it may be used in single tube circuits, and is particularly useful in radioactivity measuring instruments.

Tape Recording Head

THE INDIANA STEEL PRODUCTS CO., 6 N. Michigan Ave., Chicago 2, Ill. Model TD-704 magnetic tape recording head, used for both recording and playback, is designed for high-impedance circuits and gives best results with a track 0.2 inch



TSM

TIME SHARING MULTIPLEX

24 CHANNEL SINGLE CARRIER RADIO LINK

STORM PROOF
STATIC PROOF
SECRET
SEMI-AUTOMATIC

Complete terminal equipment occupies a double cabinet 7' wide x 2' 4" deep x 6' 6" high, and aerials may be up to 100' from the main equipment.

Write for our Bulletin No. 511 which gives further facts and figures.

Where the installation of wires or cables is hazardous or uneconomical, Standard Time-sharing Multiplex provides a thoroughly reliable telephone trunk system, easy to install and maintain. Each equipment deals with up to 24 channels, handling any kind of A.F. traffic in the 300-3400 c/s range, including teleprinter and automatic telephone signals. Time-sharing Multiplex ensures low crosstalk and noise levels, and fading does not affect speech levels. An UHF carrier is used and the normal line-of-sight range (approx. 35 miles) may be extended by automatic repeaters.

Standard Telephones and Cables Limited *Radio Division*

OAKLEIGH ROAD, NEW SOUTHGATE, LONDON, N.11, ENGLAND

R.D.7

TRANSFORMER CANS

STOCKED IN STANDARD SIZES

Let us save you die costs on all stock size transformer cans, and make IMMEDIATE DELIVERY. We carry a full range of sizes and can supply with or without covers. List of stock sizes and prints will be furnished upon request.

We are also equipped to fabricate special sizes and shapes (round, square and rectangular) of transformer cans to your own specifications. Tell us your requirements and we will be glad to submit estimates.

Important: All Craft Transformer Cans are drawn in one piece.

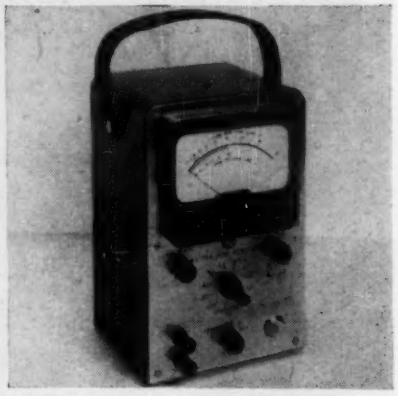
CONTACT CRAFT FOR TRANSFORMER CANS

Craft MANUFACTURING CO.
3949 W. Schubert Ave., Chicago.
Stainless Steel Specialists

wide. Using tape with a coercive force of 300 oersteds at a speed of 7½ inches per second, operating bias level at 40 kc is 1.7 ma and the audio signal current for standard recording level is 0.15 ma.

Tone Generator

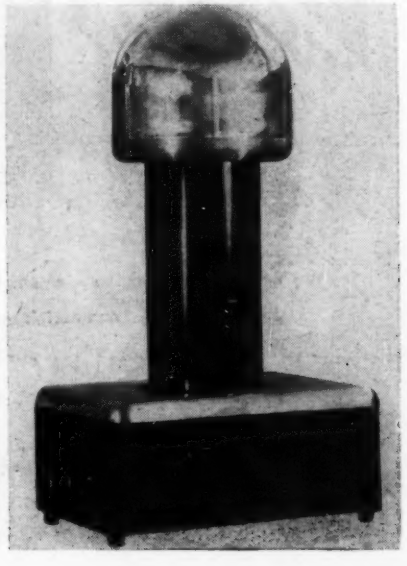
RADIO CORP. OF AMERICA, Camden, N. J. Type WA-26A portable tone generator is designed for use in broadcasting studios in equalizing



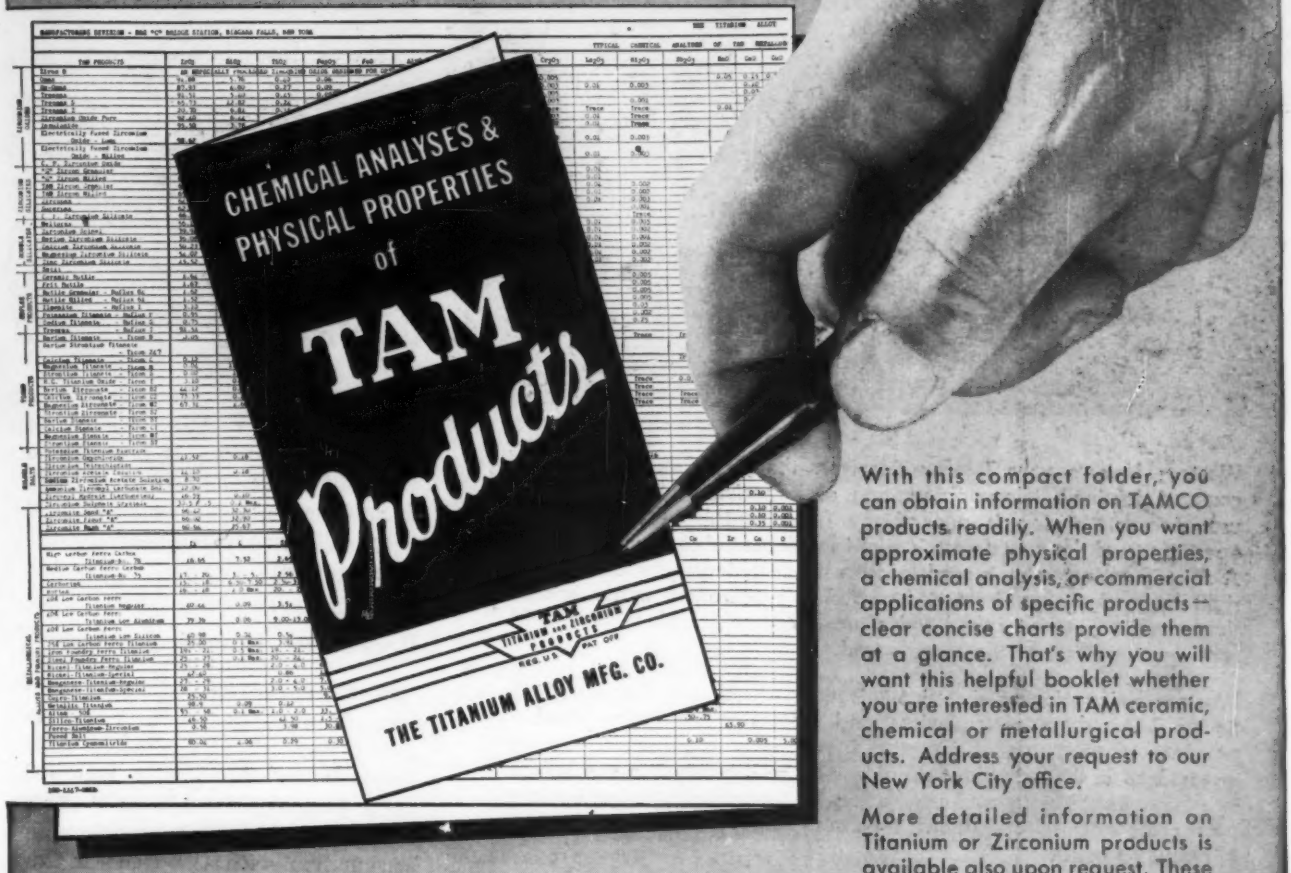
remote telephone lines. The circuit is an R-C type allowing selection of ten frequencies from 50 to 15,000 cps. Output is metered and calibrated in dbm.

High-Voltage Generator

HIGH VOLTAGE ENGINEERING CORP., 7 University Road, Cambridge, Mass., announces the model L Van de Graaff high-voltage generator which provides adjustable constant potential up to 250,000 volts. A voltmeter reads terminal



Have the facts at your fingertips


CHEMICAL ANALYSES & PHYSICAL PROPERTIES of TAM Products
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With this compact folder, you can obtain information on TAMCO products readily. When you want approximate physical properties, a chemical analysis, or commercial applications of specific products—clear concise charts provide them at a glance. That's why you will want this helpful booklet whether you are interested in TAM ceramic, chemical or metallurgical products. Address your request to our New York City office.

More detailed information on Titanium or Zirconium products is available also upon request. These data have been compiled to meet the demand for authentic information on these products from the source most closely identified with their development. It may prove advantageous to discuss certain problems and applications with our sales engineers.

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TITANIUM ALLOY MANUFACTURING COMPANY

Executive and Sales Offices: 111 BROADWAY, NEW YORK, N. Y. General Offices and Works: NIAGARA FALLS, N. Y.

Western Union's new Telefax Receiver, the Desk-Fax model, is a compact facsimile telegraph sending and receiving system for desk use. Accurate timing is one of the fundamentals of its ingenious operation and the new device is wired for dependable Haydon timing. A #1600 series motor is used to drive the scanning stylus from left to right by means of a drum and cord. The synchronous motor operation permits constant speed stylus movement and both sending and receiving units run at the same speed.

Western Union pioneers in communications, Haydon in the science of timing . . . developing devices and motors which make possible progress in all fields of industry. In addition to producing timing motors and a wide range of standard timers, Haydon also specializes in design engineering and production of custom-built timing devices for specific volume applications. Wherever timing is important, Haydon is ready to assist.

Wire or write for a Haydon representative to call. If it's time for timing, it's time for Haydon. An Engineering Data Catalog is available. For quick reference, see Haydon Catalog, Sweet's File.

WRITE 2412 ELM STREET, TORRINGTON, CONNECTICUT

HAYDON

MANUFACTURING COMPANY, INC.

TORRINGTON CONNECTICUT

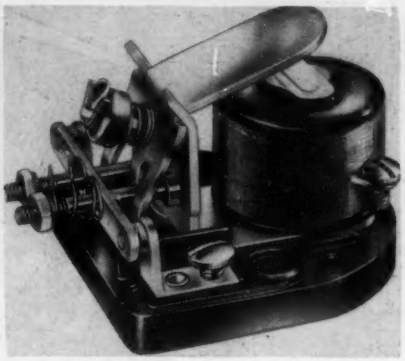
HARNESS TIME TO YOUR PRODUCTS

SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

voltage directly and a polarity reversing switch permits selection of either positive or negative voltage. The unit will operate from any 115-volt, 60-cycle, single-phase circuit fused for 20 amperes.

Motor-Starting Relay

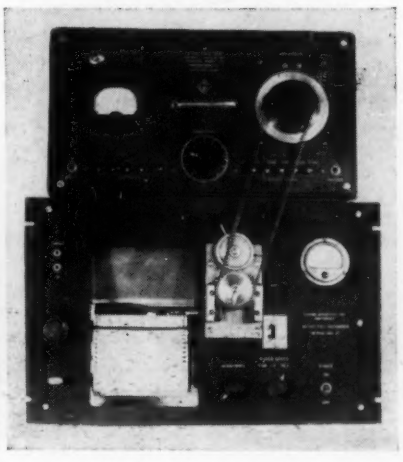
POTTER & BRUMFIELD SALES CO., 549 W. Washington Blvd., Chicago 6, Ill. The MS4A, a 3 h-p motor-starting relay, is fitted with large silver cadmium oxide contacts for



high current loads. It is available with 800-ohm winding for 115-volt 50 to 60-cycle motors or with 2,100 ohm coil for 230-volt 50 to 60-cycle motors.

Recording Sound Analyzer

SOUND APPARATUS CO., 233 Broadway, New York 7, N. Y. Frequency analysis of a complex wave from 25 to 750 cps is recorded on a 4-inch wide calibrated scale by the FR and FR-1 recorders in conjunction with the General Radio 760-A sound analyzer. Full scale



THEY BOTH HAVE IT

The EXTRA SOMETHING that spells TOP PERFORMANCE

Seletron

SELENIUM RECTIFIERS

Built on Aluminum

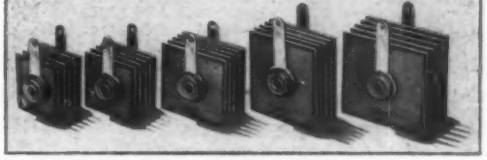
THE football star who eludes the players of the rival team and sends the pigskin hurtling down the field to a goal has "the extra something that spells top performance."

For outstanding service in every rectifier application specify Seletron Selenium Rectifiers. They have the "extra something" that spells top performance.

From the large power stacks to the miniature units for radio and television, Seletron uniformity and precision methods of manufacture insures user satisfaction. Efficient—dependable, durable under the severest service conditions.

Furnished in a wide variety of voltages and currents to meet the individual requirements.

MINIATURE SELETRON RECTIFIERS



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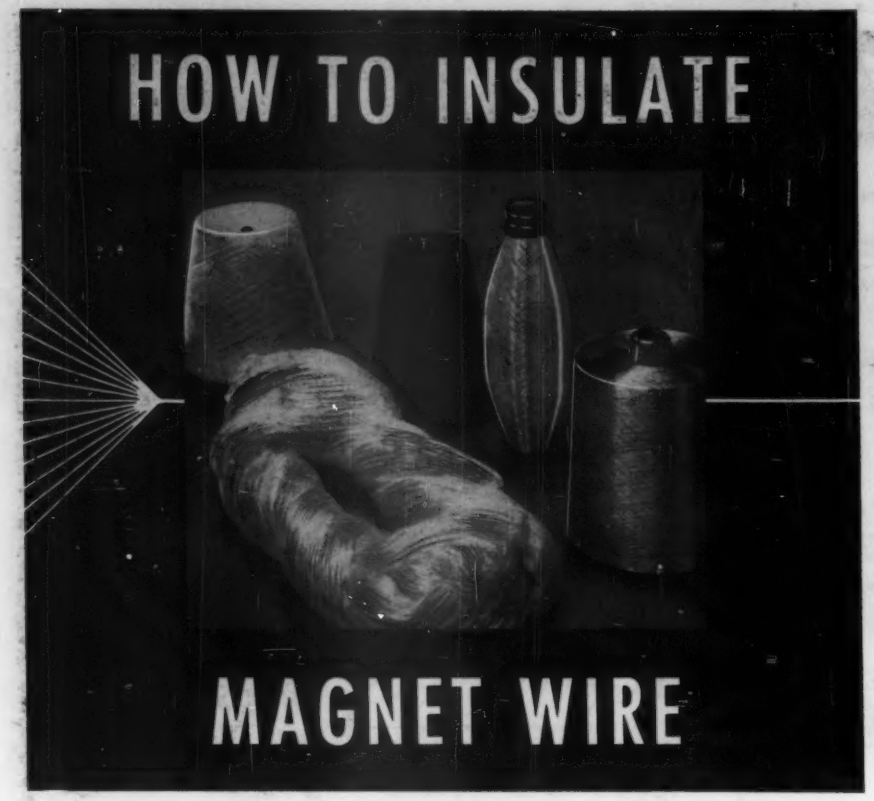
MINIATURE SELENIUM RECTIFIERS
FOR RADIO AND TELEVISION APPLICATIONS

The complete family of miniature Seletron Rectifiers is designed for use on a nominal 115 A-C line, to provide direct current for radio, television sets, amplifiers, and other low power applications. Instant starting, small size, long life and simplicity of installation are a few of many features of the Seletron Family.

CODE NUMBER	5L1	5M1	5P1	5R1	5Q1
Current Rating	75 ma.	100 ma.	150 ma.	200 ma.	250 ma.
Plate Height	1"	1"	1 1/16"	1 1/2"	1 1/2"
Plate Width	3/8"	1"	1 1/16"	1 1/4"	1 1/2"

Write today for catalog. Address Dept. ES-12

SELETRON DIVISION
RADIO RECEPTOR COMPANY, Inc.
Since 1922 in Radio and Electronics
251 WEST 19TH STREET. NEW YORK 11, N. Y.



To insulate magnet wire so that it will give long, dependable, satisfactory service, all you have to do is to purchase the finest silks, cottons, nylons, glass and celanese. Wrap these insulations in precise layers around a metal core drawn to tolerances of specified exactness and you have a really high grade magnet wire.

At Wheeler Insulated Wire Company, in Bridgeport, we've been doing this since 1905. Users of Wheeler Insulated Wire products have come to recognize our magnet wire as being of good basic design and engineering, made by skilled workmen and subject to rigid inspection. They know these qualities are to be found in every pound of magnet wire they purchase from us.

The Wheeler Insulated Wire Company can place at your disposal a staff of experienced wire engineers. Let us help you with your wire problems. There's no obligation for this service. Write today for complete information.

THE WHEELER INSULATED WIRE CO., INC.

SERVICE QUALITY WHEELER DEPENDABILITY

DIVISION OF THE SPERRY CORPORATION

1012 WASHINGTON AVENUE

BRIDGEPORT 4, CONNECTICUT

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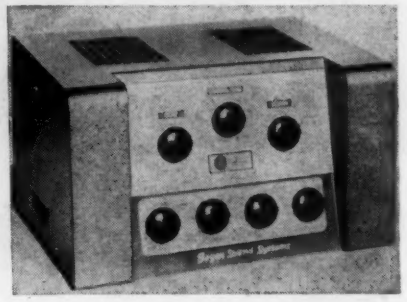
width is calibrated linearly in equal 20, 40, 60 or 80-db divisions. The recorder is separately usable as a sound, power, or voltage level recorder.

Anti-Feedback Amplifier

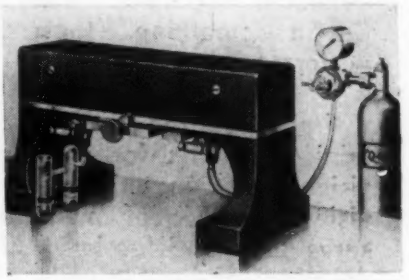
DAVID BOGEN CO., INC., 663 Broadway, New York City. The HX50 amplifier incorporates the new anti-feedback control, making microphone placement less critical. A dual tone corrector controls bass and treble ranges. Bass control is



from −20 to +20 db at 60 cycles. Treble control of +20 to −20 db at 10,000 cycles is also provided. The unit has three microphone channels and one phone input.

Geiger Counter

NUCLEAR INSTRUMENT & CHEMICAL CORP. (formerly Instrument Development Labs., Inc.) 223 West Erie St., Chicago 10, Ill. Model D-46 Q-gas Geiger counter uses a formulated gas for detection of soft ioniz-



ing radiation like that from C^{14} or S^{35}. Anode potential used is 1,450 volts. The pulse output will operate a scaling unit with an input sensitivity of 0.25 volt.

Voltage Regulators

SORENSEN & CO., INC., 375 Fairfield Ave., Stamford, Conn. The new type 5 and 10-kva voltage regulators are available in either 115 or 230-volt models. Regulation ac-

KAY ELECTRIC COMPANY

TO SERVICE PRESENT AND FUTURE T-V SETS . . .

THE MEGA-LINE OF INSTRUMENTS COVERS ALL CHANNELS

Think that statement over before you spend even a few dollars for any sweeping oscillator . . .

With any Mega-Sweep you can cover any proposed frequency . . . When any future channel, even above 500 megacycles, is added you will not have to fuss around with special adjustments or added equipment . . . or buy new equipment . . . The MEGA-SWEEP covers it with ease and accuracy . . .

The News of Radio

RCA Will Study Ultra-High Frequencies in Search for Television Channels

Plans for the study of ultra-high frequencies to determine whether they can accommodate the expansion of television broadcasting were announced yesterday by Dr. C. B. Jolliffe, executive vice president in charge of RCA Laboratories. At the same time the Radio Corporation of America applied to the Federal Communications Commission for a license to install an experimental station in Washington over which to conduct the tests, expected to start about Sept. 1.

The radio frequencies to be explored are above 500 megacycles, Dr. Jolliffe said. He explained that the spread between 475 and 890 megacycles, already set aside by the FCC for future television development, is the only part of the spectrum where television can look for more channels in view of the search for additional frequencies by other services.

New York Times 5-28-48

THE MEGA-SWEEP

Wide Range Sweeping Oscillator . . . DISPLAYS PASS BAND . . . Features: Frequency Range—50 kilocycles to 500 megacycles and up to 1000 mc . . . Frequency Sweep Adjustable from 30 megacycles to 30 kilocycles throughout the complete spectrum . . . Continuously variable attenuator . . . Low amplitude Modulation while sweeping—less than 0.1 DB per megacycle . . . Precision wavemeter. High and Low level output. Sweep voltage output for driving oscilloscope.

Price $395.00 f. o. b. factory

THE MEGA-MARKER SR

For Rapid and Accurate Alignment of Television Receivers. The MEGA-MARKER SR, provides a precise source of frequencies (accuracy .01%) one at the sound carrier in each of the twelve television channels.

MEGA-MARKER SR. can also be used alone for the alignment of the local oscillator for all twelve channels.

The single-dial control gives a rapid and efficient means of frequency selection.

The MEGA-MARKER SR. facilitates the alignment of the r. f. channels in the same manner that the MEGA-PIPPER and MEGA-MARKER facilitate the i. f. alignment.

MISC. 117 volt 60 cycle Size 8 x 16 x 8 Weight 15 pounds

Price $195.00 f. o. b. factory

THE MEGA-MARKER

Precision variable marker oscillator having a range of either 19 to 29 or 29 to 39 megacycles for the television i. f. band.

Crystal oscillator for the alignment of intercarrier i. f. and discriminator (4.5 mc).

A large easily read dial provides over 12 inches of calibrated scale length. Thus it may be read to accuracies of 0.02 megacycles.

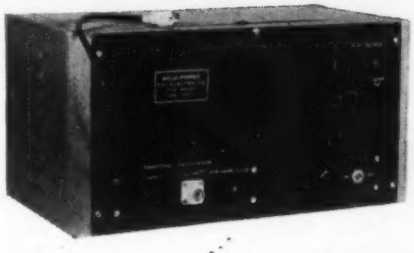
Included in the MEGA-MARKER is a crystal oscillator which provides accurate check points.

The MEGA-MARKER is a valuable accessory for television applications of the MEGA-SWEEP and MEGA-MATCH.

For a high order of stability the regulated power supply of the MEGA-SWEEP or the MEGA-MATCH is used.

Weight 5 lbs. size 7 x 10 x 6

Price $60.00 f. o. b. factory



THE MEGA-PIPPER

The MEGA-PIPPER is a new production and service alignment instrument. By the use of this unit in conjunction with the MEGA-SWEEP or MEGA-MATCH it is possible to quickly and accurately align television i. f. amplifiers.

The MEGA-PIPPER gives four precise crystal positioned pips. These pips establish the picture and sound i. f. carrier points, and also the adjacent channel carrier points. Thus the MEGA-PIPPER is an instrument which will save many hours of time spent in alignment.

Inasmuch as the pips are fed directly into an oscilloscope, the pips are visible at all times, even in the traps where the highest precision is desired.

Self contained power supply.

Weight 15 lbs. Size 6 x 16 x 8

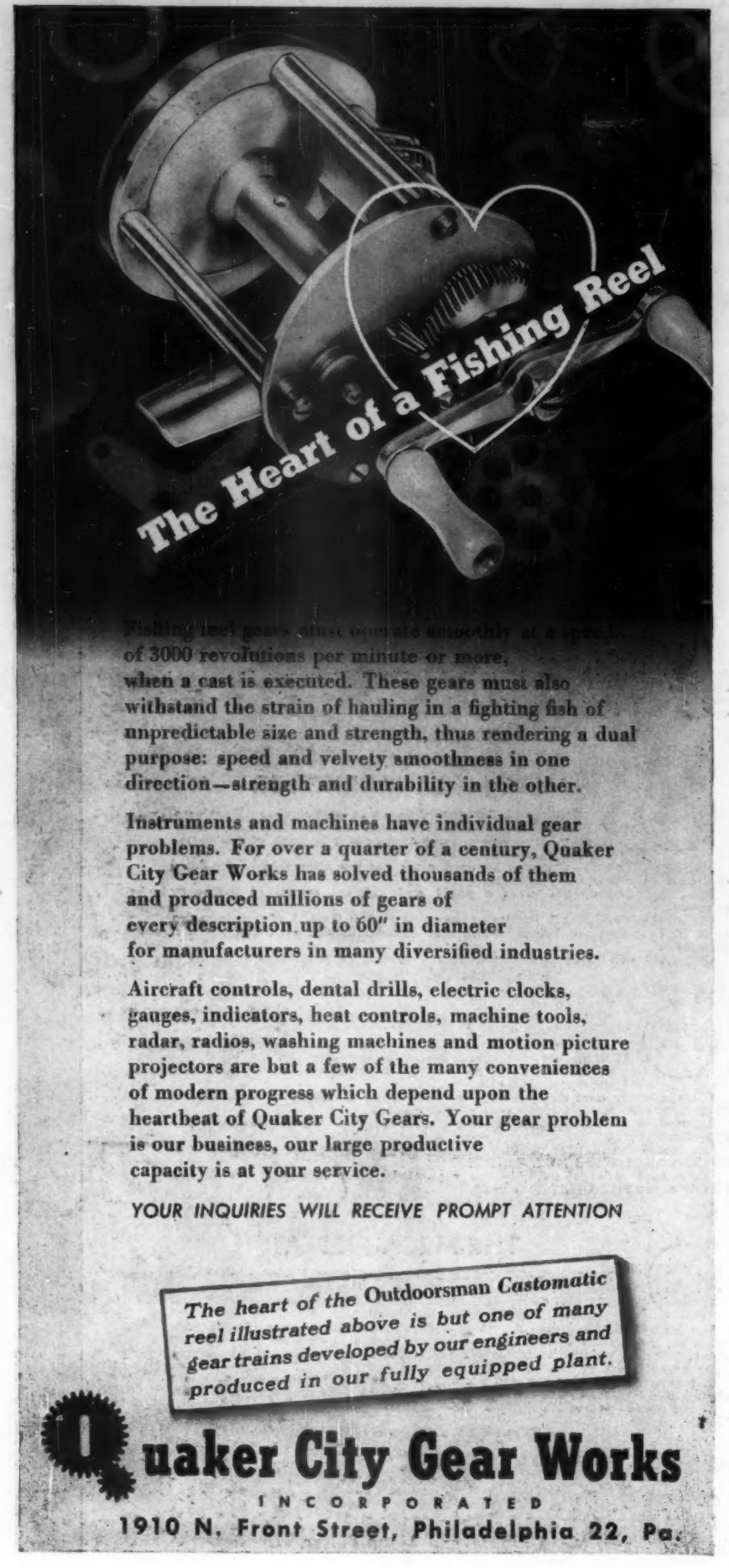
Price $150 f. o. b. factory

WRITE FOR FULL SPECIFICATIONS

KAY ELECTRIC CO., 25 MAPLE AVENUE, PINE BROOK, N. J.

Also Manufacturers of the Megalyzer, Mega-Match and Mega-Pulser.

INSTRUMENTS



Fishing reel gears must operate smoothly at a speed of 3000 revolutions per minute or more, when a cast is executed. These gears must also withstand the strain of hauling in a fighting fish of unpredictable size and strength, thus rendering a dual purpose: speed and velvety smoothness in one direction—strength and durability in the other.

Instruments and machines have individual gear problems. For over a quarter of a century, Quaker City Gear Works has solved thousands of them and produced millions of gears of every description up to 60" in diameter for manufacturers in many diversified industries.

Aircraft controls, dental drills, electric clocks, gauges, indicators, heat controls, machine tools, radar, radios, washing machines and motion picture projectors are but a few of the many conveniences of modern progress which depend upon the heartbeat of Quaker City Gears. Your gear problem is our business, our large productive capacity is at your service.

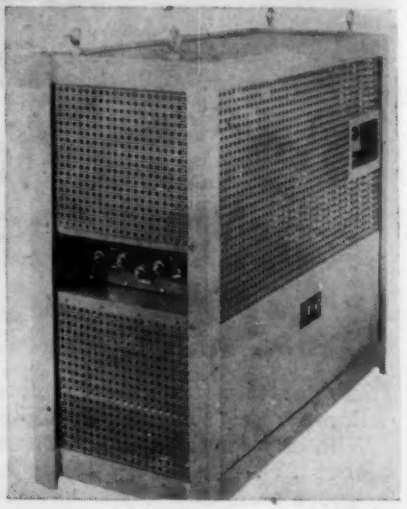
YOUR INQUIRIES WILL RECEIVE PROMPT ATTENTION

The heart of the Outdoorsman *Castomatic reel illustrated above is but one of many gear trains developed by our engineers and produced in our fully equipped plant.*

Quaker City Gear Works

INCORPORATED

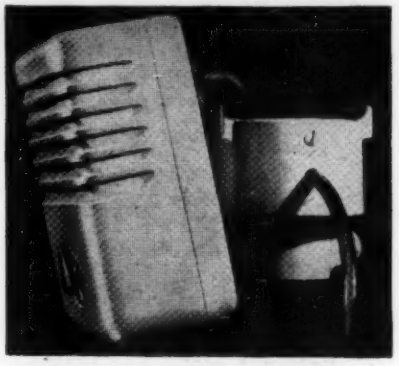
1910 N. Front Street, Philadelphia 22, Pa.



curacy is 0.5 percent. Line frequency changes between 50 and 60 cycles do not affect output voltage or performance of either regulator. For further information ask for catalog S-348.

Loudspeaker Unit

TARRYTOWN METALCRAFT CORP., 82 Chestnut St., Tarrytown, N. Y. The Han-D-Vox speaker unit is available in both indoor and outdoor models for theatre installations. Enclosed in a cast-aluminum case,



it contains a 4-inch permanent-magnet speaker and a constant-impedance sound control or L-pad whereby line impedance is matched and maintained.

Code Machine

ULTRADYNE ELECTRONICS, Oswego, Oregon. Designed for radio telegraph instruction, the radio code machine RCM-1 sends at speeds between 4 and 80 words per minute. The many available types of tape serve particular functions of instruction, and although the overall

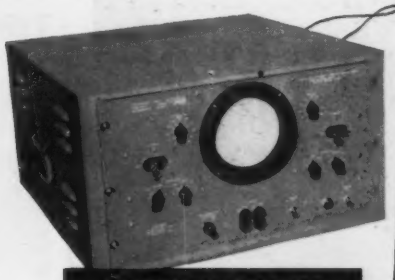
For wider frequency range...top writing rates... increased brightness...it's DU MONT *High-voltage Oscillography*

The basis is the Type 5RP-A Cathode-ray Tube operating at an accelerating potential up to 29,000 volts maximum. This achieves: (1) Greatly increased brightness; (2) Observation or recording of traces hitherto invisible; (3) Vastly increased writing rates even better than 400 inches per microsecond; (4) Optical magnification by projection lenses such as Du Mont Type 2542. Although deflection sensitivities are slightly less than those of low-voltage cathode-ray tubes, high-voltage oscillographs produce smaller spot size and higher brightness, thereby presenting a finer, better resolved trace.

And here's the Du Mont selection of high-voltage oscillographs:

10 CPS to 10 MC

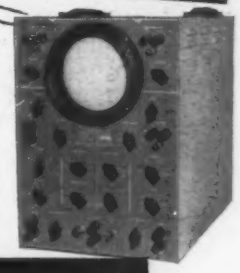
Type 280: A precision time-measuring oscillograph with range of 10 cps to 10 mc. Sweep speeds as high as 0.25 microsecond/in. are available. Duration of any portion of signal measured on 0.25 microsecond/in. sweep to an accuracy of ±0.01 microsecond. Intervals greater than 5 microseconds read on calibrated dial to accuracy of ±0.1 microsecond. Ready application to precise measurement of duration of waveform of various components in the composite television signal. Accelerating potential adjustable from 7,000 to 12,000 volts. Recordable writing rates up to 63 inches per microsecond, with commercially available equipment.



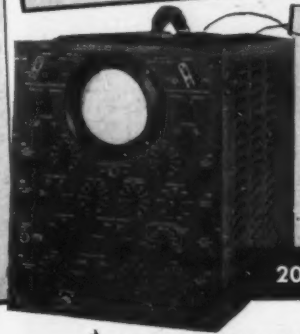
WRITING RATES TO ABOVE 400 IN./MSEC.

Type 281-A: Devoid of internal deflection amplifiers, there are no frequency response limitations within the ratings of its Type 5RP-A tube. Phenomena have been recorded photographically at writing speeds of 85 inches per microsecond. With external power supply (such as Du Mont Type 286-A), photographic writing speeds of over 400 inches per microsecond may be examined. Recommended when oscillographic needs are extremely specialized or too advanced for standard commercial equipment. An accelerating potential as high as 29,000 volts is available with the Types 281-A and 286-A in combination.

Type 250-H: Covers range from d-c to 200 kc. Potentials containing both d-c and a-c components may be examined. Many special features for general usage include: linear time-base of unusual flexibility; automatic beam control on driven sweeps; internal calibrator of signal amplitude. This is a high-voltage oscillograph with maximum accelerating potential of 13,000 volts. Recordable writing rate of approximately 40 inches per microsecond.



D-C to 200 KC



20 CPS-5 MC

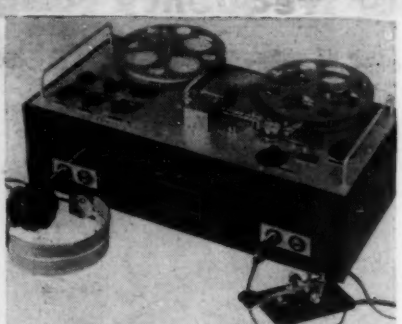
Type 248-A: Frequency range of 20 cps to 5 mc. Specifically intended for investigation of pulses containing high-frequency components of recurrent or transient nature. For this purpose it provides these necessary characteristics: High-frequency recurrent sweeps; short-duration driven sweeps; timing markers; signal delay network. Accelerating potentials up to 14,000 volts at recordable writing rate of approximately 69 inches per microsecond.

LITERATURE ON REQUEST

© ALLEN B. DU MONT LABORATORIES, INC.

DU MONT *for Oscillography*

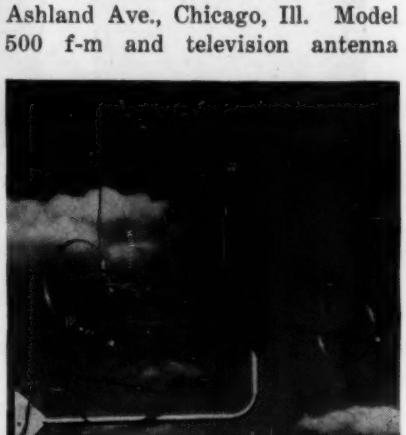
ALLEN B. DU MONT LABORATORIES, INC., PASSAIC, N. J.
CABLE ADDRESS: ALBEEDU, NEW YORK, N. Y., U.S.A.



speed of a tape may be 5 wpm, the characters are keyed individually at between 15 and 20 wpm. Brochures are available.

Tele and F-M Antenna

TRICRAFT PRODUCTS CO., 1535 N. Ashland Ave., Chicago, Ill. Model 500 f-m and television antenna



shown weighs only 2½ pounds and is provided with 300-ohm line to the receiver.

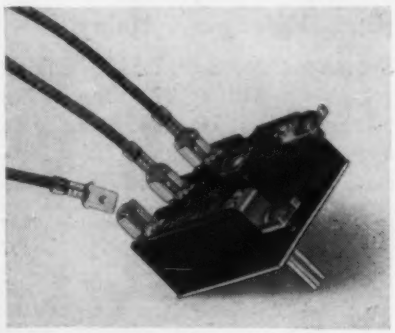
Carrying Case

RADIO CORP. OF AMERICA, Harrison, N. J. Especially designed for transporting test and measuring equipment, the new carrying case

WG-274 is an aid to a-m, f-m and television servicing. Extra storage compartment at right provides space for test leads, adaptors, probes and other accessories. List price is $16.95.

Wiring Connector

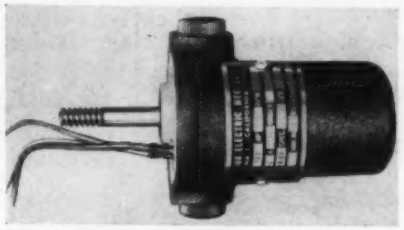
ARK-LES SWITCH CORP., 55 Water St., Watertown 72, Mass., has developed a new disconnect terminal designed to speed the wiring of electrical equipment. A flat blade staked to the connecting wire snaps



into a rigid receptacle in which it is retained by spring pressure. The unit features low contact resistance. The terminal assembly illustrated lists at a rating of 20 amperes, 125–250 volts a-c.

Electric Motor

MISSION ELECTRIC MFG. CO., 132 West Colorado Blvd., Pasadena, Calif. The new electric motor with 0.005-horsepower rating has an



rpm rating of 5,000 to 20,000 under load and 10,000 to 40,000 free speed. The unit weighs less than 11 ounces.

Photocounter

POTTER INSTRUMENT CO., INC., 136-56 Roosevelt Ave., Flushing, N. Y. Model 310 photoelectric counter can be used at rates up to 6,000 per minute. Last digit of the number is registered on neon glow lamps and the rest of the digits are indi-

An Important Statement

by

MYCALEX

CORPORATION OF AMERICA

As illustrated on the opposite page, PHILCO uses Mycalex 410 (glass bonded mica) molded parts in its television receiver tuner – to avoid frequency drift of tuned circuits.

Your attention is also called to the Mycalex 410 advertisement which appeared on pages 54 and 55 of the October 1948 issue of Electronics.

Constant research, improved technics, advances in the art, new, modern plant expansion, improved engineering, more efficient manufacturing equipment—now permit us to make available in increased quantities—Mycalex 410—molded—*at prices comparable* to other less efficient molded insulations.

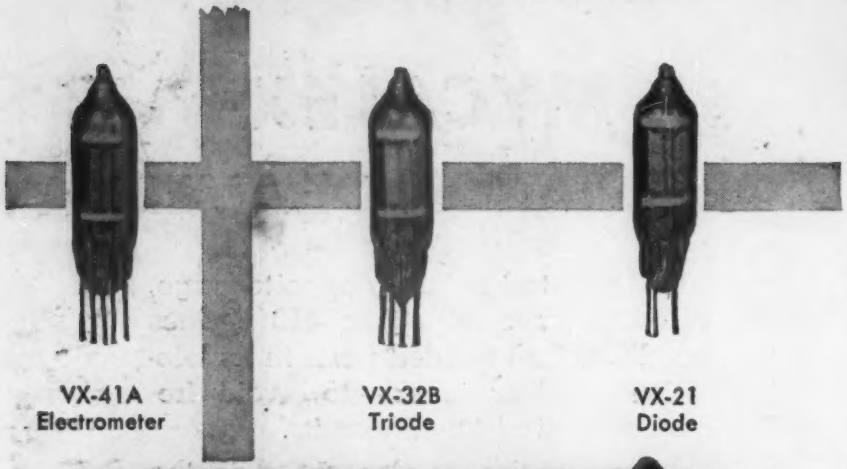
MYCALEX 410 is now priced to meet rigid economy requirements

Any interest evidenced on your part in Mycalex products and services—will receive the prompt, courteous and intelligent attention of a competent Mycalex sales engineer. He will receive the fullest backing and cooperation from other factory executives—to serve you promptly—with a quality product and at an economical and fair price.

SINCE 1919 MYCALEX THE INSULATOR

Components which are contributing an essential service in the progress of radiation instrumentation.

10 mil-filament subminiature tubes



VX-41A Electrometer

VX-32B Triode

VX-21 Diode

1B85

The new 1B85 Thyrode is a thin rib re-enforced aluminum self-quenched, beta-gamma counter tube operating at 900 volts. Wall thickness 30 mg/sq. cm.

RMA TYPE 1B67 has been assigned to the standard laboratory mica window self-quenched, beta thyrode which operates at 1200 volts. Window thickness 2.0 to 2.6 mg/sq. cm. Other thicknesses on request.

1B67/VG-10A

1B87

The new 1B87 sub-miniature Thyrode is designed to operate at 900 volts with a plateau greater than 100 volts and a nominal background counting rate of 12 counts per minute.

Hi-Meg

Hi-Meg resistors

Hi-meg resistors vacuum sealed, from 10^8 ohms to 10^{13} ohms measured to within 1% accuracy are a symbol of reliability in all ion chamber radiation measuring instrument and electrometer circuits.

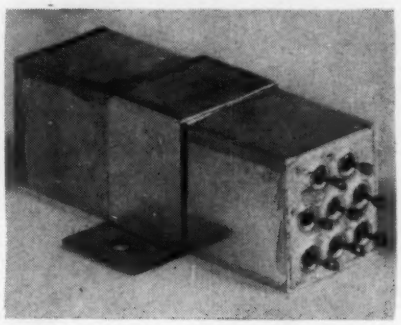
Victoreen

5806 HOUGH AVENUE CLEVELAND 3, OHIO

cated on the mechanical register that accommodates up to seven digits. The complete system is priced at $185.

Ultra-High-Speed Relay

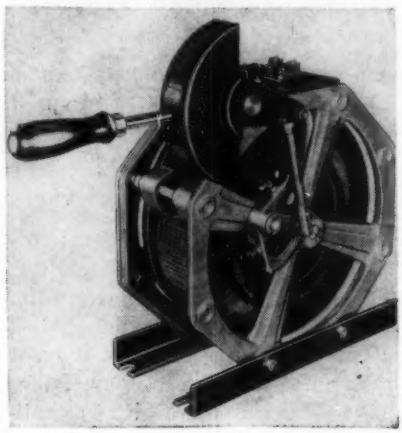
STEVENS-ARNOLD INC., 22 Elkins St., South Boston 27, Mass. The Millisec relay, formerly spdt, is now made 4 pole, double throw, hermetically sealed. It will operate as



fast as $\frac{1}{3}$ millisecond and has a life expectancy of 22 to 100 million operations. Contact rating is 110 volts d-c, 0.5 ampere.

Dimmers

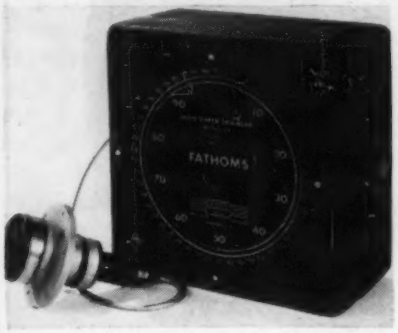
SUPERIOR ELECTRIC CO., Bristol, Conn. Switchboard dimmers for use in theaters and television studios are available in the form of continuously variable autotransformers. Two types are provided



with output range from 0 to 1,700 watts and also 0 to 4,600 watts. Group control is conventionally arranged with coupling to a common shaft.

Echo Depth Sounder

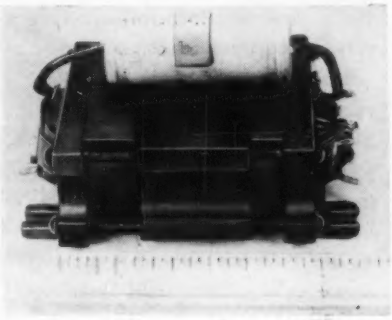
KAAR ENGINEERING CO., Middlefield Road, Palo Alto, Calif. The ES-29 electronic echo depth sounder has



an indicator scale calibrated to 100 fathoms plus, and a power drain of about 30 watts. It is available for input voltages of 6, 12, 32 and 110 volts d-c. The unit uses an ultrasonic transducer of the inboard crystal type which both transmits and receives ultrasonic waves.

Voltage Stabilizer

RAYTHEON MFG. CO., Waltham, Mass. The VR-6000 miniature 5-watt stabilizer operates at an input



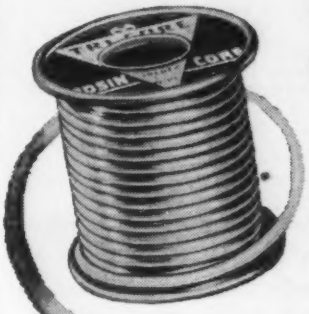
voltage of 95 to 130 volts a-c, 60 cycles, single phase. Output is 120 volts stabilized to ±0.5 percent.

Transformer Assembly

SPELLMAN TELEVISION CO., INC., 130 W. 24th St., New York 11, N. Y., has developed a high-voltage corona shielded, tuned transformer assembly which includes an octal socket

FOUND! A WAY TO CUT PRODUCTION COSTS 25% AND STILL IMPROVE QUALITY

ALPHA TRI-CORE Rosin-filled SOLDER



Three cores for the price of one! Speedier action! More operations per pound of solder! Test after test in radio plants has proved that Alpha Tri-Core is more efficient and more economical than conventional solders. Our engineers will be glad to demonstrate these dollar-saving features in your plant. There is no obligation; just call on us.

CHECK THESE FEATURES

Alpha TRI-CORE ROSIN-FILLED Solder

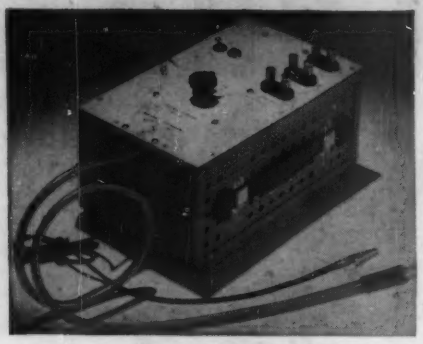
* 99.9% pure, water-white rosin used exclusively!
* Non-activated! No rejects due to corrosion!
* Adapted to your production needs: an American solder designed for American production; manufactured and stored here ready for delivery!
* No toxic, obnoxious fumes!
* 25% more joints per hour per pound of solder!
* Cut your solder cost with Tri-Core's — 5 to 15% less tin and still get better results than possible with other solders using more tin.
* Tri-Core available in diameters as large as ¼", and heavier—down to .020" and finer.

Alpha

other ALPHA PRODUCTS include: TRI-CORE "ENERGIZED" ROSIN-FILLED SOLDER; TRI-CORE "LEAK-PRUF" ACID-FILLED SOLDER, SOLID SOLDER WIRE; PREFORMS (rosin and acid-filled); BAR SOLDER, ANODES AND FOIL.

ALPHA METALS, INC., 371 HUDSON AVENUE, BROOKLYN 1, NEW YORK

QUANTITATIVE MEASUREMENTS
ON HIGH IMPEDANCE CIRCUITS



MODEL 102

PHANTOM REPEATER

AN INSTRUMENT AMPLIFIER WITH 200 MEGS.—6.0 MMF INPUT IMPEDANCE

The Phantom Repeater bridges voltmeters and cathode ray oscilloscopes, which have inputs of 1 megohm and 30 mmf, onto signal circuits of 50,000 ohms and higher —such as a pentode amplifier stage with its high resistance plate load—without the loss of voltage and high frequency response which would result if the measuring instruments were connected directly. Input Impedance: 200 megohms shunted by 6 mmf. Output Impedance: 300 ohms. Gains of 1.00, 10.0, and 100. Frequency Range from 5 cps to 150,000 cps within 2%. Background noise equivalent to 40 to 70 microvolts at the input.

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for BETTER VIDEO REPRODUCTION

Acme Electric engineers will cooperate with your engineering department by providing specially designed transformers for power supply and other applications in an effort to improve the reception and reproduction qualities of your sets.

Acme Electric can produce transformers of special characteristics from standard parts which means that our enormous manufacturing facilities and quality controlled production results in buying economies for you.

Send us specifications and application outline.

ACME ELECTRIC CORP.

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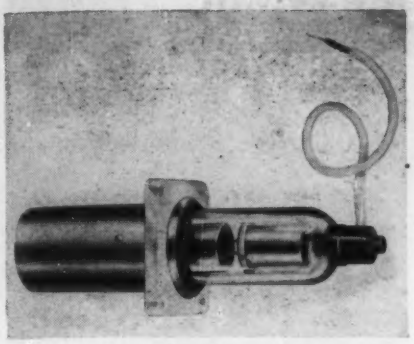
Acme ACME Electric
TRANSFORMERS



for use with 1B3-8016 type tube. Adjustable filament voltage allows the tube to be used for voltages from 1 kv to 20 kv. The unit is designed to operate in conjunction with r-f step-up coils of approximately 200-kc frequency.

Voltage Stabilizer

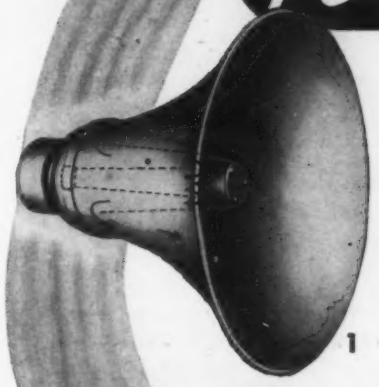
RAYTHEON MANUFACTURING CO., Waltham, Mass. A new model in the VR-6000 line of voltage stabilizers is hermetically sealed and oil-filled. Power rating is 15 watts.

The unit provides 115 volts stabilized to plus or minus 1 percent for inputs of 95 to 125 volts in the frequency range 57 to 63 cycles.

Oscillator Improvement

KAY ELECTRIC CO., Maple Ave., Pine Brook, N. J., has added tone

RACON
ADVANCED ENGINEERING
Gives you RACON SUPERIOR PERFORMANCE



A horn or speaker of conventional type may resemble a Racon horn or speaker in *outward appearance*. But close examination of a Racon unit reveals *internal differences*—refinement of design, better mechanical construction, sturdier materials and other special features that represent ADVANCED ENGINEERING. It is these exclusive features that give you superior performance in any Racon unit. Higher efficiency over wider ranges. Freedom from distortion. Uninterrupted service. The long life that protects your investment.

1 —RACON-RE-ENTRANT TRUMPET RE-35. Designed to deliver highly concentrated sound over long distances. Air column 3½'. Inside tone arm aluminum castings; bell, heavy aluminum spinnings; center reflecting section, RACON PATENTED ACOUSTIC MATERIAL to prevent resonant effects. Ruggedly built. Length 16", bell diam. 18". Swivel ratchet or U bracket mounting.

2—RACON RE-ENTRANT RADIAL TRUMPET SR-35R. Has all of the construction features of RE-35 such as non-vibratory center section, heavy aluminum castings, etc. All reflecting surfaces of RACON PATENTED ACOUSTIC MATERIAL to prevent resonant effects prevalent in all large reflecting surfaces. Delivers sound with even intensity over a 360° circumference. Length 16"; width 17". Type SR-60R length 34½"; width 36".

3—PERMANENT MAGNET HORN UNITS. Highly popular in all types of service. Many improvements. Two groups with Alnico V Magnets and Alnico Blue Dot Magnets. Steel parts plated to prevent corrosion. Also fitted with corrosion proof metal or plastic diaphragms. Voice coil impedance on all units: 15 ohms. Special ohmages on request.

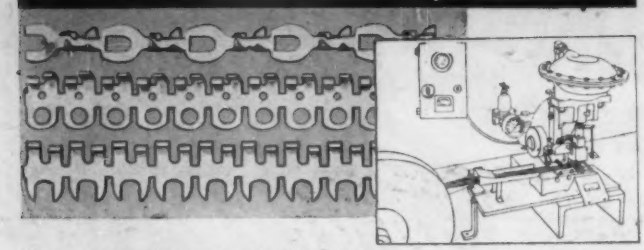
NOW FURNISHED WITH WATERPROOF CASING
All units may now be had with heavy spun aluminum cases, forming a hermetically sealed, watertight housing for outdoor use, at slight extra cost.

Write for Catalog of complete Racon Line

RACON ELECTRIC CO., INC.
52 E. 19th Street New York, N. Y.

RACON Speakers Horn Units Horns

Now Terminals Can Be ATTACHED & SOLDERED *in ONE Automatic Operation!*



The greatest innovation in attaching terminals to wires is now available to the industry . . . "Pre-soldered" TANDEM TERMINALS! Made in various sizes and types, these remarkable, production-proved terminals (supplied on reels) can be applied at rates up to 1200 per hour by a new Terminal Attaching Machine that cuts off, clinches and solders terminals in one instantaneous operation. Handling of loose terminals, solder and flux are eliminated to reduce costs and boost production on long runs. Standard types available. Send for detailed information, enclose sample of wire and terminal now used.

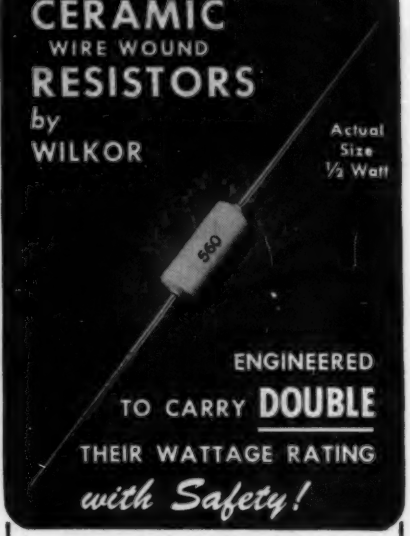
For ordinary runs in moderate quantity we continue to produce

SEPARATE TERMINALS for ELECTRIC WIRES

We also make SMALL METAL STAMPINGS Exact to Customer's Prints. Modern Plant and Equipment. Moderate Die Charges. Precision Work. Prompt Service.

PATTON-MacGUYER COMPANY
17 Virginia Avenue, Providence, R.I.

CERAMIC WIRE WOUND RESISTORS by WILKOR



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• **WILKOR WC-type wire-wound resistors are fully ceramic insulated and engineered to withstand tremendous overloads, as well as either high or low temperatures. In use by manufacturers of radio, television and other electronic instruments.**

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Available in . . .

½ to 10 watt sizes, 1-10,000 ohms.

In Tolerances of . . .

1%, 2½%, 5%, 10%, 20%.

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WILKOR Ceramic Resistors assure you greater . . .

DURABILITY
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Write for specification sheet. Samples available for quantity users.

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Now! Specify KENYON

KENYON one of the oldest names in transformers, offers high quality specification transformers custom-built to your requirements. For over 20 years the KENYON "K" has been a sign of skillful engineering, progressive design and sound construction.

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Yes, *electronification* of modern industrial machinery and methods has been achieved by KENYON'S engineered, efficient and conservatively rated transformers.

For all high quality sound applications, for small transmitters, broadcast units, radar equipment, amplifiers and power supplies — Specify KENYON! *Inquire today for information about our JAN approved transformers.*

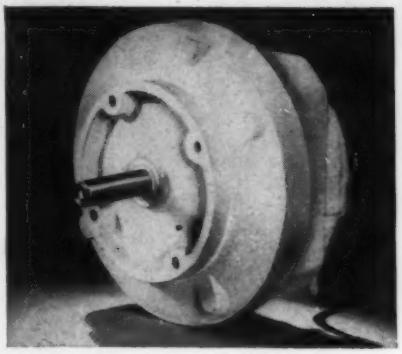
Now — for the first time in any transformer catalog, KENYON'S new modified edition tells the full complete story about specific ratings on all transformers. Our standard line saves you time and expense. Send for the latest edition of our catalog *now!*

KENYON TRANSFORMER CO., Inc. 840 BARRY STREET, NEW YORK 59, N.Y.

modulation to the Mega-Marker Sr. oscillator for television testing. The modulation may be switched on or off. By its use, the local oscillator may be aligned by using only the Mega-Marker Sr. and the television sound channel and loudspeaker.

Single-Bearing Motor

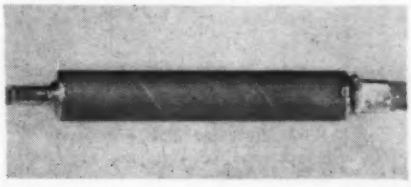
ELECTRO-ENGINEERING PRODUCTS CO., INC., 4824 W. Kinzie St., Chicago 44, Ill., has developed a single bearing motor to provide accurate lineup in air gap. It is



of the four-pole type with a no-load speed of 1700 rpm and a full-load speed of 1550 rpm. The unit is designed for such applications as wire recorders, turntables and fans.

Fuse Protection

THE CLEVELAND CONTAINER CO., 6201 Barberton Ave., Cleveland 2, Ohio. The Cosmalite enclosing tube for the indicating secondary fuse



illustrated protects the fuse chamber, fuse link, and all operating parts.

Binary Scaler

GENERAL ELECTRIC CO., Syracuse, N. Y. Model 4SN1A1 binary scaler, designed for use in nucleonic and computer applications, counts electrical impulses at speeds up to 200 kc in either binary or decade operation. A 5 to 20-volt negative input pulse of 1 microsecond dura-

AN ENTIRELY NEW

Dependable

AUTOMATIC DEHYDRATOR

BY

Andrew

For pressurizing coaxial systems with dry air

WRITE FOR BULLETIN 85

Now, for the first time, here is an automatic dehydrator that operates at line pressure! This means, (1) longer life, and (2) less maintenance and replacement cost than any other automatic dehydrator.

Longer life because the compressor diaphragm operates at only 1/3 the pressure used in comparable units, vastly increasing the life of this vulnerable key part.

Reduced maintenance and replacement costs because new low pressure design eliminates many components.

Operation is completely automatic. Dehydrator delivers dry air to line when pressure drops to 10 PSI and stops when pressure reaches 15 PSI. After a total of 4 hours' running time on intermittent operation, the dry air supply is turned off and reactivation begins, continuing for 2 consecutive hours. Absorbed moisture is driven off as steam. Indicators show at a glance which operation the dehydrator is currently performing.

Output is 1¼ cubic feet per minute, enough to serve 700 feet of 6⅛" line; 2500 feet of 3⅛" line; 10,000 feet of 1⅝" line or 40,000 feet of ⅞" line. Installation is simple, requiring only a few moments.

Important! Not only is this new differently designed Andrew Automatic Dehydrator completely reliable, but it is available at a surprisingly low price.

Andrew CORPORATION

363 E. 75th STREET, CHICAGO 19

Eastern Office:
421 Seventh Avenue, New York City

ANDREW

TRANSMISSION LINES FOR AM, FM, TV. DIRECTIONAL ANTENNA EQUIPMENT. ANTENNA TUNING UNITS. TOWER LIGHTING EQUIPMENT. CONSULTING ENGINEERING SERVICE.

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ANDREW CORPORATION, 363 E. 75th St., Chicago 19

Please send me Bulletin 85 describing the new Type 1900 Andrew Automatic Dehydrator.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

EL-12-48

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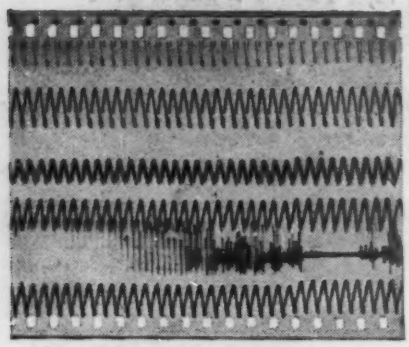


TRANSIENT EVENTS ARRESTED

The first Avimo Oscillograph Recorder was a specially built Camera designed to provide Records of Cathode Ray Traces to a scale which permitted accurate measurement, side by side on continuous film, so that precise relationships could be determined.
Success in this specialised field led to demands for Cameras to record other kinds of transient events, so that within the Avimo range listed below there are, to-day, Instruments to meet nearly any requirement of the Research or Laboratory worker.
The wide experience gained in the course of this development is at your disposal and Avimo engineers will be glad to submit suggestions if you will state your problem.

GROUP	FUNCTION
A. Continuous Recording.	For recording oscillograph traces on 35 mm. or 70 mm film.
B. Single Shot.	For use where phenomena are constant.
C. Combined Continuous and Single Shot.	Provides the functions of Groups A or B as desired.
D. Drum.	For high-speed drum recording of high-frequency phenomena on 35mm. film.
E. Multi-Channel Recorders.	With built-in Cathode Ray Tubes for continuous recording of up to 15 traces.
F. Instrumentation Cine.	Provides a pictorial record of several variants over a period of time.

There is no reasonable limit to the film speeds which may be provided and recorders of Groups A, B, C & D may be used in conjunction with any standard oscillograph.

AVIMO

AVIMO LIMITED
TAUNTON (SOM.), ENG.

3½ KW
VACUUM TUBE
BOMBARDER
or
INDUCTION
HEATING UNIT

Only $975

Never before a value like this 3½ KW bombarder or high frequency induction heater . . . for saving time and money in surface hardening, brazing, soldering, annealing and many other heat treating operations. Is

Portable . . . mounted on four rubber coasters. Width 14½"; depth 27"; height 42½"; weight 300#.

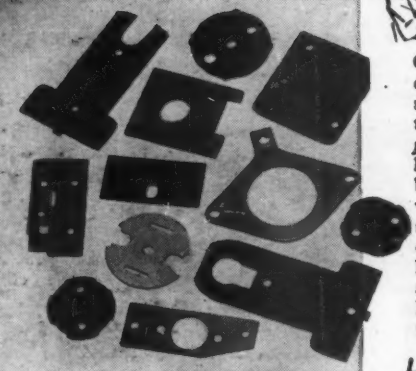
Operates from 220 volt line. Complete with foot switch and one heating coil made to customer's requirements. Send samples of work wanted. We will advise time cycle required for your particular job. Cost, complete, only $975. Immediate delivery.

Scientific Electric Electronic Heaters are made in the following ranges of power: 1-2-3-5-7½-10-12½-15-18-25-40-60-80-100-250. KW.

Scientific Electric

Division of
"S" CORRUGATED QUENCHED GAP CO.
105 - 119 Monroe St., Garfield, N. J.

Baer offers accurate fabrication of phenol and vulcanized fibre!



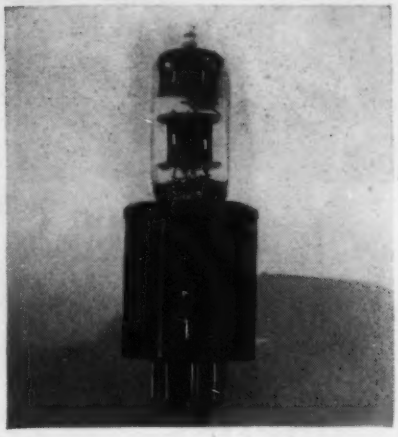
SEND BLUEPRINTS AND SPECIFICATIONS— NO OBLIGATION!

Check BAER FIBRE for accurate dimensioning, uniform surface, mechanical and electrical qualities, and *low cost per piece.* See how efficiently a BAER FIBRE terminal board, bushing, gasket, washer or other shape can simultaneously solve your electrical or mechanical problem...improve your product... and save you money! BAER FIBRE is precision fabricated to your specifications.

LITERATURE ON REQUEST

N. S. BAER COMPANY
MONTGOMERY ST., HILLSIDE, N. J.

* Baer facilities are unexcelled for stamping, punching, drilling, tapping, shaving, milling, shearing and sawing.



tion and 0.1 minimum rise time will produce an output pulse of 50 volts, peak to peak. Resolution time is 5 microseconds and output impedance is 27,000 ohms.

Tube Tester

HICKOK ELECTRICAL INSTRUMENT Co., 10527 Dupont Ave., Cleveland 8, Ohio. Model 533 DM display

tube tester is a dynamic mutual conductance type. Flexibility is provided by a system of selector switches.

Small Blower

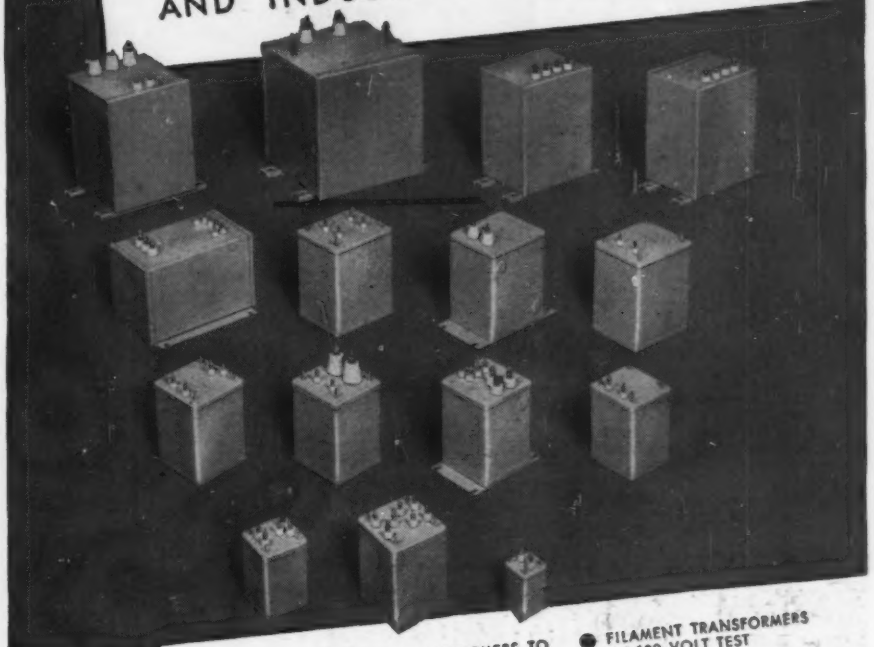
GLOBE INDUSTRIES, INC., 125 Sunrise Place, Dayton 7, Ohio. The MB-1 blower unit comprises a 0.01-hp aircraft-type d-c motor with centrifugal impeller. At rated voltage, the unit will produce 20 cubic feet per minute. The unit operates at 11,000 rpm with an in-

New! All inclusive!

N Y T

STANDARD LINE OF TRANSMITTER COMPONENTS

FOR AM, FM AND TV—LABORATORY AND INDUSTRIAL APPLICATIONS



INCLUDING—

- PLATE TRANSFORMERS TO 10 KVA
- FILTER REACTORS
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FEATURING—

- 115/230 VOLT, 50/60 CYCLE SUPPLY
- RUGGED INTERNAL CONSTRUCTION, SUPPORTED CORE STRUCTURE
- EYE BOLTS ON LARGE UNITS FOR EASY HANDLING
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- EFFICIENT MAGNETIC AND ELECTRO-STATIC SHIELDING
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Here is one of the finest and most complete lines of standard transmitter components available today. Built to the same well-known high standards as N·Y·T custom-built units, they bring to the design engineer the full economy of standardized construction. Superbly constructed, inside and out, each unit fully reflects the years of experience that have made the name NEW YORK TRANSFORMER synonymous with quality, integrity and dependability wherever inductive components are used.

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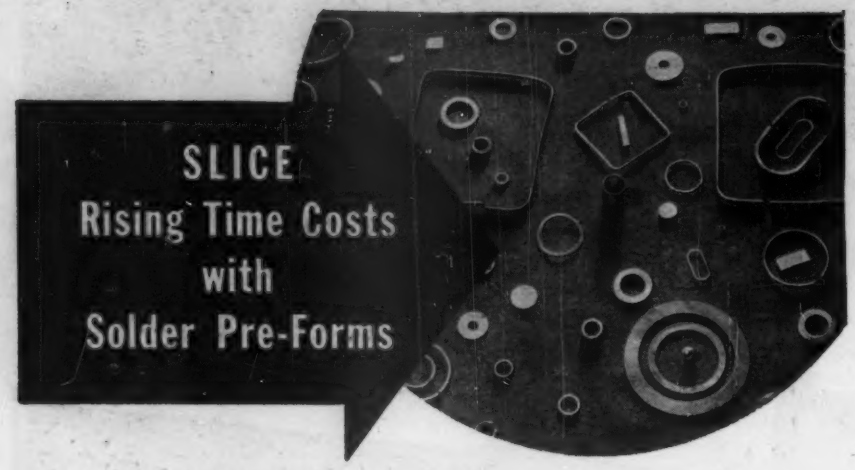
ALPHA, NEW JERSEY



SLICE
Rising Time Costs
with
Solder Pre-Forms

Eliminate time-consuming manual solder operations in your assembly processes. Pre-formed rings, washers, discs, pellets, squares, etc., complete with flux, save time, trim labor costs, insure cleaner, more uniform, sturdier bonds. We meet your specifications in the widest variety of solder alloys. Consult with us on any solder or brazing problem.

(Literature on Request).

Soldering Specialties

Dept. C, Summit, N. J.

—high accuracy plus!

For Instrumentation and other critical applications

IN-RES-CO wire wound resistors are engineered for the manufacturer maintaining a reputation of top quality and performance in his equipment. They cover a full range from 1 watt to 10 watts and .01 ohm to 1.5 megohm. Conservative ratings assure maximum long life; trouble free service. Write for catalog today on company letterhead.

TYPE BX—
1 WATT

NON-INDUCTIVE

MAX. RES: 1.5 Megohm (331 Alloy)
1.0 Megohm (Nichrome)
10,000 Ohms (Manganin)
BODY SIZE: 1" lg. by 9/16" diam.
TOLERANCE: STANDARD 1%
(TO 1/10% at Slight Extra Cost)

TYPE CX—
½ WATT

NON-INDUCTIVE

MAX. RES: 750,000 ohm (331 Alloy)
500,000 ohm (Nichrome)
15,000 ohm (Manganin)
BODY SIZE: 5/8" lg. by 9/16" diam.
TOLERANCE: STANDARD 1%
(TO 1/10% at Slight Extra Cost)

IN-RES-CO
APPLICATION-DESIGNED
RESISTORS
IN-RES-CO

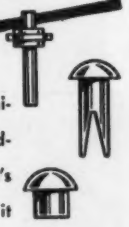
INSTRUMENT RESISTORS CO., 1056 COMMERCE AVE., UNION, N. J.

SAVE

- MATERIALS
- MAN-HOURS
- MONEY

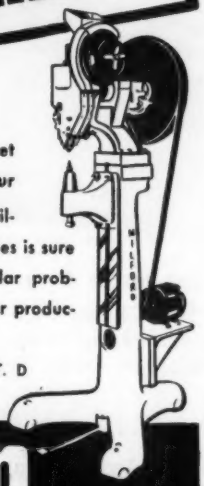
with the . . .

RIGHT RIVETS



Select exactly the right semi-tubular, split rivet, or cold-headed fastener from Milford's complete line. You'll find it pays in every way!

RIGHT MACHINE



Then use the right rivet setting machine for your application. One of Milford's 15 basic machines is sure to solve your particular problem . . . and slash your production costs!

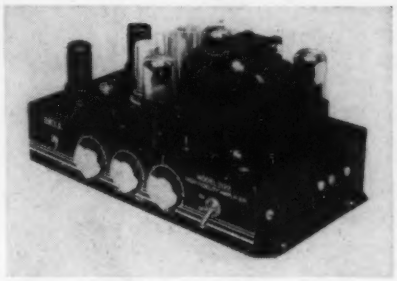
WRITE TO DEPT. D

Penn RIVET & MACHINE COMPANY
254 Huntingdon Street
PHILADELPHIA 33, PENN.

put of 14.5 watts. A fan unit is also available separately. Motor can be used as part of a vibrator unit in a stall warning system for planes.

Phono Amplifier

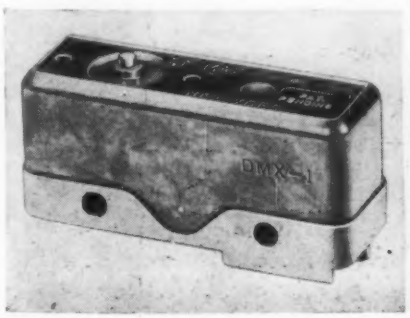
BELL SOUND SYSTEMS, INC., Columbus 7, Ohio. Model 2122 high-fidelity radio-phono amplifier has four input circuits, built-in preamplifier for each of two magnetic pickup



inputs, as well as bass and treble boost. Peak power output is 15 watts. Response is essentially flat from 30 to 15,000 cycles. Send for sheet Lit 4849-2A.

Precision Switch

UNIMAX SWITCH DIVISION OF THE W. L. MAXSON CORP., 460 W. 34th St., New York 1, N. Y. Type DMX universal precision switch has spst silver contacts capable of handling



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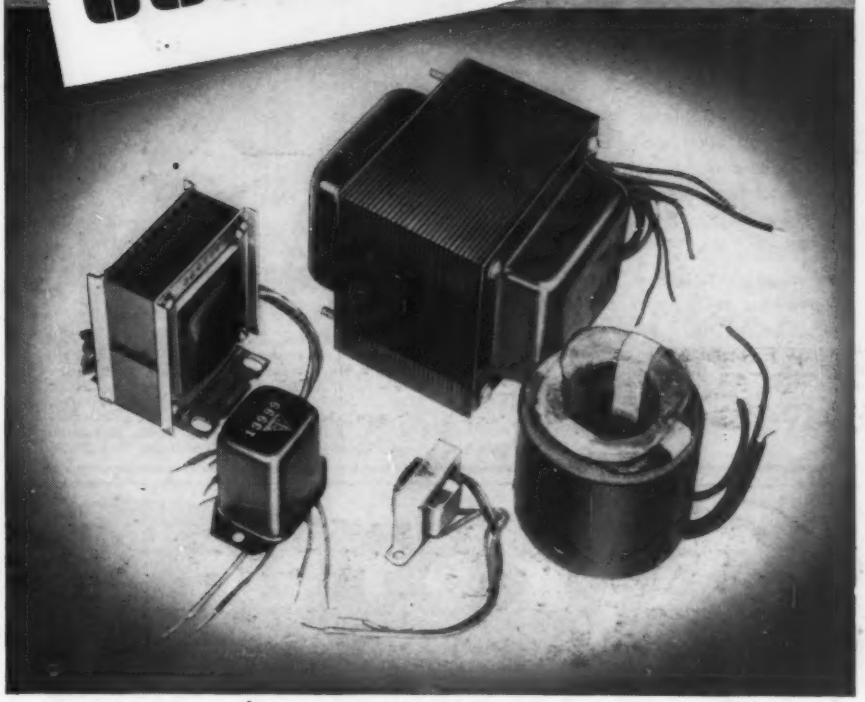
TELEVISION COMPONENTS



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★ DEFLECTION COILS
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Available Now!

N.Y.T. facilities are now expanded to supply all types of inductive television components in quantity. Estimates will be supplied promptly on standard units or types wound to your exact specification. In addition to television components, N.Y.T. offers complete manufacturing service on power transformers, chokes, and audio transformers. Modern plant and winding equipment assures finest quality at low cost. Call or write today for information.

★ IN ANY QUANTITY!

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it's in the groove... ...and out!

High speed machine-winding of electric motor armatures necessarily exposes magnet wire to some rugged treatment.

The all-around (in the groove and out) "windability" of ESSEX EXTRA TEST MAGNET WIRE in this and other exacting applications cannot be excelled.

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Plants: Anaheim, Calif.; Detroit, Mich.; Fort Wayne, Ind. Warehouses* and Sales Offices: *Atlanta, Ga.; *Boston, Mass.; *Chicago, Illinois; Cleveland, Ohio; Dallas, Texas; Dayton, Ohio; *Detroit, Mich.; *Kansas City, Mo.; *Los Angeles, Calif.; Milwaukee, Wis.; *Newark, N.J.; Philadelphia, Pa.; *Portland, Oreg.; *St. Louis, Missouri; *San Diego, Calif.; *San Francisco, California

COOLER OPERATION

KOTRON

STRIP-TYPE

SELENIUM RECTIFIERS

PATS. PEND.

100 MA. UNIT

- Max. A. C. line input 130 volts rms
- Max. inst. peak current 1000 Ma.
- Max. inverse peak voltage 360
- Average operating temp. 105°F
- Dimensions: 4-1/16" x 1-1/16" x 5/32"
- Other Sizes: 75 Ma. and 200 Ma.

Kotron's metallic rectifying elements are mounted in one plane. Plates cannot contribute heat to each other. Result—Cooler Operation . longer life . . . increased circuit efficiency. Wafer-thin Kotron saves space, mounts easier.

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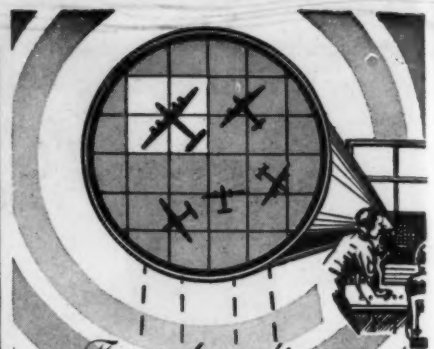

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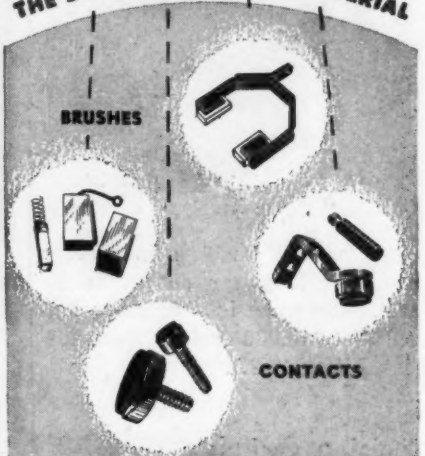

in BRUSHES
for high current density ○ minimum wear ○ low contact drop ○ low electrical noise ○ self-lubrication

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for low resistance ○ non-welding character

GRAPHALLOY works where others won't! Specify GRAPHALLOY with confidence.

*A special silver-impregnated graphite

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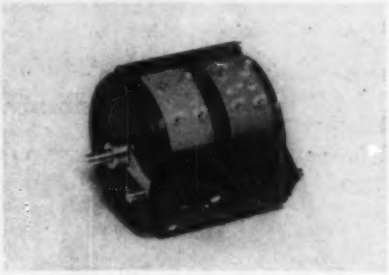
10 amperes at 125 volts, either a-c or d-c. It features a focused-flux alnico magnet, a ceramic baffle chamber and an arc-resistant molding on base and cover.

Precision Pot

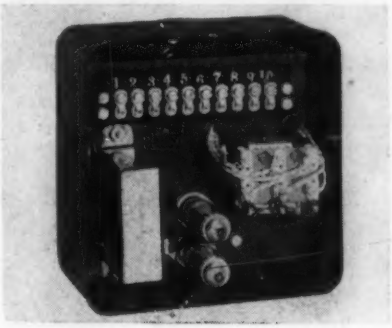
TECHNOLOGY INSTRUMENT CORP., 1058 Main St., Waltham, Mass. The new 2-in. potentiometer illustrated



has a linearity of 0.2 percent and has a maximum electrical rotation of 320 degrees. Designed particularly for computer and similar applications, the units are available only on special order.

Welding Water Control

ROBOTRON CORP., 56 Manchester, Highland Park (Detroit) 3, Michigan. The Robotector model 22B01A

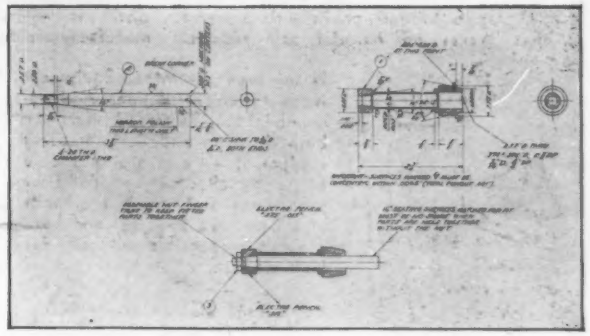


protects an idle welding transformer from excessive condensation and acts as a simple fail-safe electronic circuit. Further details are given in a catalog sheet.

Metal Locator

FISHER RESEARCH LABORATORY, INC., Palo Alto, Calif. The new M-Scope conveyor belt locator detects metal objects as small as a dime on conveyor belts and automatically interrupts the power circuit to stop the line. The unit pictured will accommodate a belt 2 ft

with STEEL — the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished product.



with TRACING CLOTH . .

The small extra first cost of Arkwright Tracing Cloth, over that of tracing paper, repays many times over in the efficiency and durability of valuable drawings.

Your investment in Arkwright Tracing Cloth is a trifling sum, compared to its returns in drawings kept permanently sharp and repeatedly useful!

Foresighted drafting departments regularly specify fine-woven, expertly bonded Arkwright, rather than perishable tracing paper, for *every drawing worth keeping for possible future use.*

Read the *Big Six Reasons* why Arkwright Tracing Cloth eases work, improves jobs, resists wear and time. Then send for generous samples and prove this superiority on your drawing board. Sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
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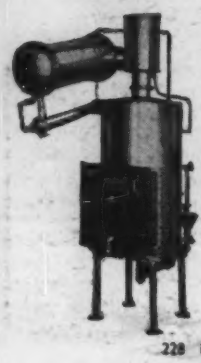
Only Barnstead

Can Offer You "GRADED WATER" for Parts Rinsing and Screen Processing

With Barnstead Water Stills or Demineralizers (or a combination of both) you can be assured of a constant unvarying supply of high resistance water exactly fitted to your needs. Where the use requires only the removal of mineral content, Barnstead 2-Bed, 4-Bed or Type "R" Upflo Models provide rinse water that leaves no harmful salt residue.

If the requirements demand elimination of organic impurities as well as inorganic, Barnstead Water Stills provide the surest and most economical answer. For such exacting uses as on screens of cathode ray tubes it may be necessary to de-ionize the water first and then distill it — as many leading tube manufacturers do.

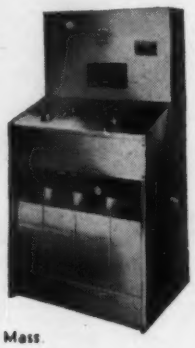
TYPE "SS" WATER STILL



In any event, Barnstead Equipment is your safest solution. And remember, only Barnstead offers you both distilling and demineralizing equipment — and are thus able to handle all situations. Put your pure water problems in the hands of a Barnstead Engineer and have a single responsible authority for their solution.

We will be glad to supply recommendations for your particular problem without obligation.

TYPE "R" UPFLO DEMINERALIZER



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STILL & STERILIZER CO.
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PURE WATER SPECIALISTS FOR OVER 70 YEARS"

Do you need a DRY BATTERY you can't find?

There is a **SPECIALTY DRY BATTERY** for your special need

If you are looking for hard-to-get or special dry batteries, write us. We design, create and manufacture to your requirements.

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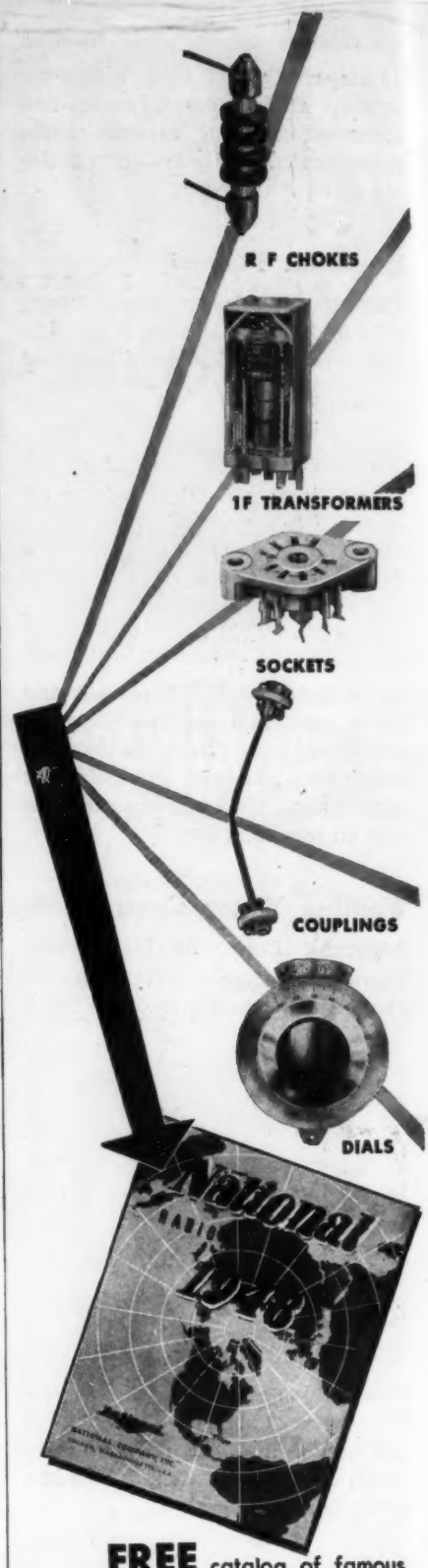
MADISON 4, WISCONSIN



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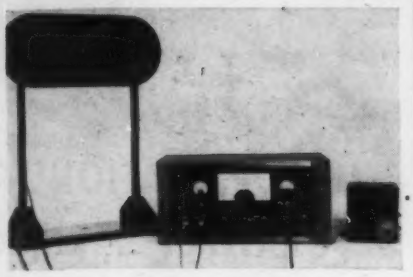


wide with a load 2 ft. high. Loop antennas can be adjusted for different heights and widths.

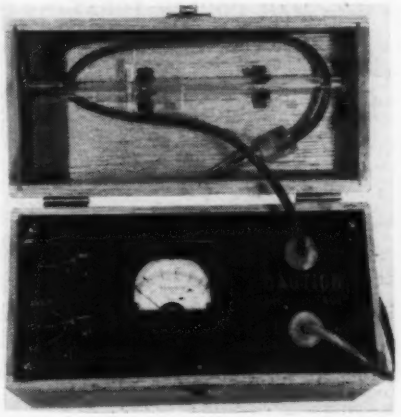
Hand Hearing Aid

DICTOGRAPH PRODUCTS, 580 Fifth Ave., New York, N. Y. The Hearette is a hand-held type of hearing aid that is intended both for people

with slight hearing loss and those with normal hearing who may wish to use a selective system in auditoriums or other places where noise level is high.

Kilovoltmeter

BETA ELECTRONICS CO., 1762 Third Ave., New York 29, N. Y. Series 121 multirange kilovoltmeters have full-scale range of 15 and 30, and



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For Inverting D. C. to A. C. . . .

Specially Designed for operating A. C. Radios, Television Sets, Amplifiers, Address Systems, and Radio Test Equipment from D. C. Voltages in Vehicles, Ships, Trains, Planes and in D. C. Districts.

ATR AUTO RADIO VIBRATORS

New Models

A Complete Line of Vibrators . . .

Designed for Use in Standard Vibrator-Operated Auto Radio Receivers. Built with Precision Construction, *featuring* Ceramic Stack Spacers for Longer Lasting Life.

New 36 page VIBRATOR GUIDE FREE

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New Models

For DEMONSTRATING AND TESTING AUTO RADIOS

New Models . . . Designed for Testing D. C. Electrical Apparatus on Regular A. C. Lines. Equipped with Full-Wave Dry Disc Type Rectifier, Assuring Noiseless, Interference-Free Operation and Extreme Long Life and Reliability.

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Vol. 20. Edited by Britton Chance and E. F. MacNichol, University of Penn.; and R. I. Hulsizer, M.I.T. 528 pages, $7.00

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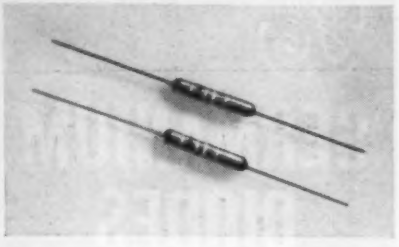

eratures without deterioration owing to a new plastic impregnant. Rated for service between minus 50 and plus 125 C, the new units are described in bulletin 211.

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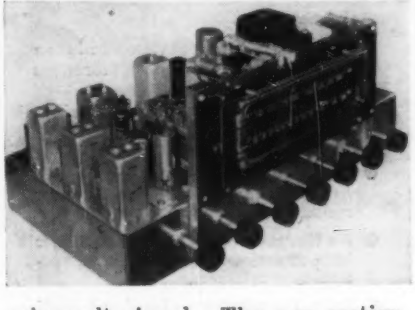

microvolt signal. The a-m section has a variable-width i-f from 8 to 18 kilocycles adjustable from the front panel. Audio output is at 20,000 ohms.

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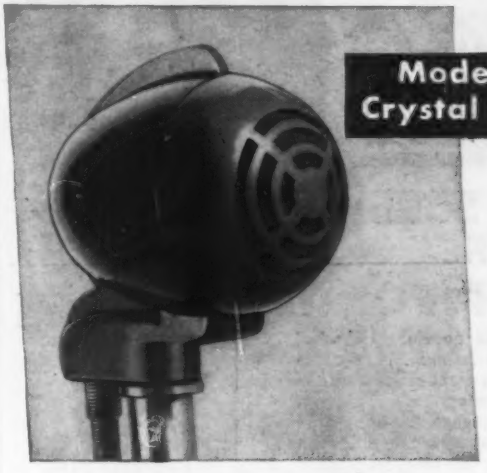

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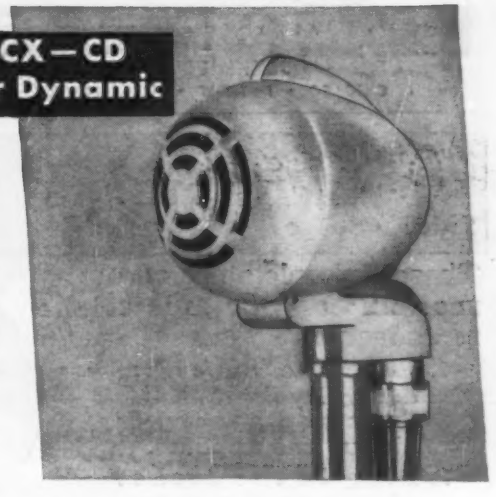

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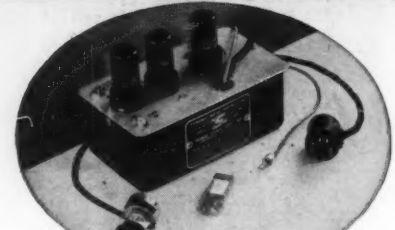

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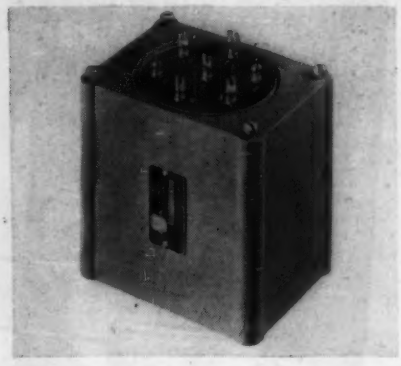

000 cycles, and plus or minus 2 db from 30 to 20,000 cycles respectively. Hum pickup, leakage reactance, as well as harmonic and intermodulation distortion have been reduced to a minimum.

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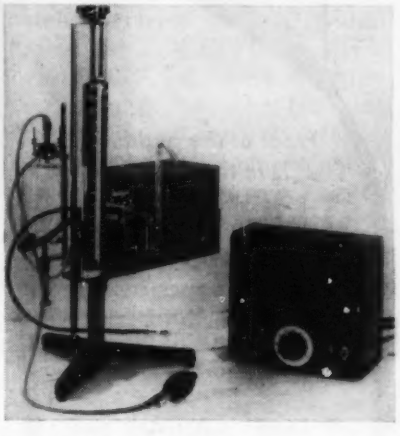
SANBORN CO., 39 Osborn St., Cambridge, Mass. The electric manometer illustrated is used for graphic registration of rapidly



fluctuating pressures as well as steady pressures. Standard ranges are 0-to-1 mm of mercury to 0-to-400 mm. Negative and mean pressures can also be measured.

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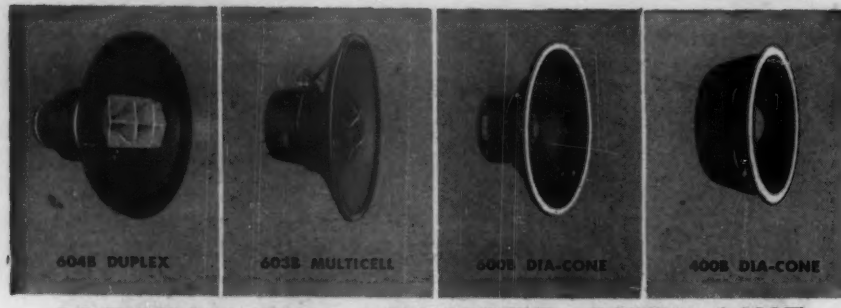

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0-500 VOLTS D.C. AT 300 MA. WITH POSITIVE OR NEGATIVE GROUND

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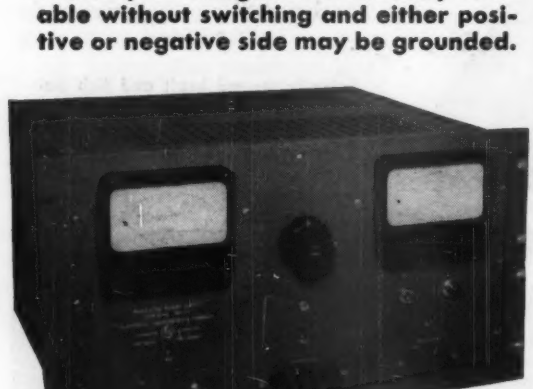

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High Voltage: 0-500 Volts D.C. continuously variable (Without switching).
Current: 300 Ma.
Low A.C. Voltage: 6.3 Volts A.C. at 6 amps. center-tapped, unregulated

REGULATION
Within 1% for voltage between 30-500 volts, from no load to full load.
Within 1% for line voltage variations from 105 to 125 volts at full load current for any voltage between 30-500 volts and within 2% at 10 volts.

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Within 10 Millivolts at any voltage or load within ratings.

LINE INPUT
105-125 Volts A.C. 50-60 cycles.

OUTPUT TERMINATIONS
High and low voltage outputs available from front and rear of unit. Positive or negative terminal of high voltage output may be grounded as desired.

Detailed specifications will be forwarded upon request without obligation.

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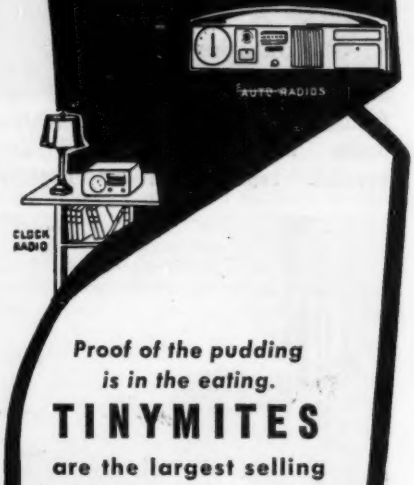

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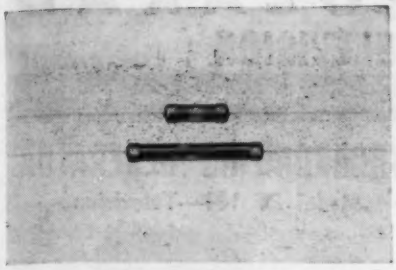

to 20 megohms. See technical bulletin B-4 for further data.

Literature

Carrier Systems. Lenkurt Electric Co., 1113 County Road, San Carlos, Calif. Form CX42 is a 12-page booklet providing a comprehensive illustrated listing of carrier telephone and telegraph systems. Also included is a description of signaling equipment and test apparatus for system maintenance.

Sound Services. Reeves Sound Studios, Inc., 304 E. 44th St., New York 17, N. Y. A recent brochure describes and illustrates the wide variety of sound recording facilities, experience and technical knowledge available for turning out films or disc production.

Nuclear Charts. Westinghouse Electric Corp., Box 1017, Pittsburgh 30, Pa., has prepared six lithographed wall charts in two colors illustrating the important areas of nuclear physics. Measuring 25 by 36 inches and made of heavy stock, the charts are accompanied by a 32-page book of supplementary information. Complete set may be purchased at the above address for $1.00.

Classroom Radio. Radio Manufacturers Association, 1317 F St., N. W., Washington 4, D. C. The present thinking of radio manufacturers and educators specializing in audio education is summarized in a recent booklet. Contents cover utilization, teaching with radio, considerations for purchase and technical considerations.

Electronic Controls. Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill. Bulletin Z6500 contains an illustrated and de-

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- Dual outputs for feeding two 75 or 100 lines
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- Resolution greater than 600 lines

INPUT: Vertical and Horizontal Driving pulses. Camera and Kinescope Blanking Pulses.

OUTPUT: Composite Video Signal, 3 volts, 100 ohm line 115 volts 50/60 cps. Complete with tubes and including high and low voltage power units.

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scriptive listing of standard instrument models including indicators, controllers, recorders, and combustion safeguards. A separate price list is also available.

Precision Switches. Unimax Switch Division of the W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y. A 20-page booklet on precision switches provides engineering data on force and movement specifications, dimensions and electrical ratings.

High-Voltage Supply. Instrument Development Laboratories, 223-233 West Erie St., Chicago 10, Ill. A single sheet illustrates and gives technical data on the model 1090 high-voltage supply which delivers 0 to ± 5,000 volts continuously variable, for ionization measurements and other low drain applications. Output voltage variation is less than 0.1 percent for a line voltage change of 95 to 130 volts.

Instrumentation System. Automatic Temperature Control Co., Inc., 5212 Pulaski Ave., Philadelphia 44, Pa. Detailed engineering and application data on the Atcotran instrument system for electrically measuring mechanical motions or displacements may be found in the 8-page catalog R-10.

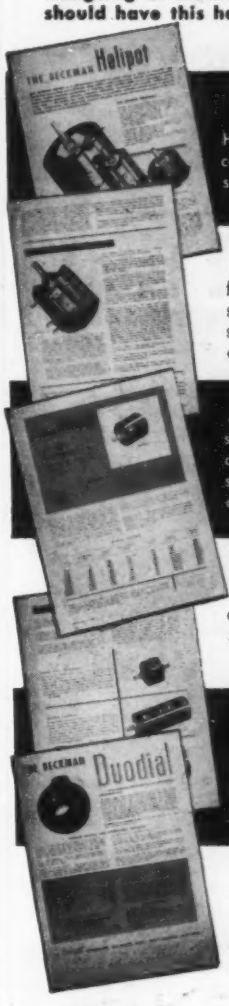
Shipboard Radar. Radiomarine Corp. of America, 75 Varick St., New York 13, N. Y. Booklet MS-15 completely describes and illustrates the CR-101 radar designed for commercial shipping. Dimensional digrams and specifications are given.

Ham Inductors. E. F. Johnson Co., Waseca, Minn. Now available is a new catalog dealing with air-wound ham inductors and plug-in swinging link assemblies. Instructions are provided which enable the amateur to select the correct coil and link for individual application.

Dry-Type Transformers. Lindberg Engineering Co., 2444 West Hubbard St., Chicago 12, Ill., recently released bulletin 1110 which gives applications, design and construction of a standard line of dry-type transformers, and also covers types for special applications.

Do you have This Helpful Helipot and Duodial Catalog?

Do you have complete data on the revolutionary new HELIPOT—the helical potentiometer-rheostat that provides many times greater control accuracy *at no increase in panel space*?... or on the equally unique DUODIAL that greatly simplifies turns-indicating applications? If you are designing or manufacturing any type of precision electronic equipment, you should have this helpful catalog in your reference files...



It Explains – the unique helical principle of the HELIPOT that compacts almost *four feet* of precision slide wire into a case only 1¾ *inches* in diameter—over *thirty-one feet* of precision slide wire into a case only 3½ *inches* in diameter!

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It Describes – and illustrates the various special HELIPOT designs available—double shaft extensions, multiple assemblies, integral dual units, etc.

It Gives – full details on the DUODIAL—the new type turns-indicating dial that is ideal for use with the HELIPOT as well as with many other multiple-turn devices, both electrical and mechanical.

If you use precision electronic components in your equipment and do not have a copy of this helpful Helipot Bulletin in your files, write today for your free copy.

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Curtis Type "K" Lock-In Terminal Blocks —factory-assembled from 1 to 18 terminals—assure dependable "lug security". Solder-type spade lugs are rigidly held in position when binder screws are tightened. No danger of terminals pulling or dropping out of position . . . yet any terminal may be easily and quickly removed by loosening screw. Screws insulated to ground.

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When you hear the Newcomb "Red Knob" record condition compensator for the first time, we are sure you'll agree it's really a *"Dream Come True."* These two great Newcomb Amplifiers with the "Magic Red Knob" do wonders in eliminating needle scratch and record distortion while retaining the maximum natural brilliance.

Of course, it's, not only this remarkably effective scratch control that gives you the extreme quality achieved by these two amplifiers. Their measured performance is superb. In *every* respect, they represent the ultimate in technical perfection, *and in addition,* there's a listening quality that even performance curves do not tell. That's why we ask you to be sure and hear these two Red Knob Amplifiers before you buy. Both have built in Pre-Amplification for G.E. or similar variable reluctance type pickups, plus inputs for AM-FM radio and crystal pickups, and the finest of tone controls.

Both are individually, and completely, custom tested to insure each unit will be "Laboratory Perfect." A "Certificate of Performance" accompanies each amplifier. Look for it. It is your assurance of individual perfection.

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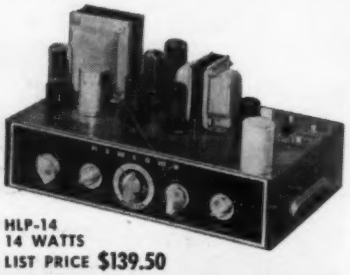
KXLP-30
30 WATTS
LIST PRICE $225.00



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THEORY OF SERVOMECHANISMS

Vol. 25. Edited by H. M. JAMES, Purdue Univ.; N. B. NICHOLS, Taylor Instrument Co.; and R. S. PHILLIPS, Univ. of Southern Calif. 375 *pages, illus., $5.00*

Here is a coherent description of the theory and mathematics involved in standard methods of servomechanism design, showing application of current techniques, and providing an introduction to a new technique. It covers frequency response design considerations—transfer loci, attenuation vs. log-frequency plots, phase-angle vs. log-frequency plots—and explains the later method which depends upon minimization of rms error with which the mechanism produces a desired result in the presence of electrical noise and other disturbances.

TECHNIQUE OF MICROWAVE MEASUREMENTS

Vol. 11. Edited by C. G. MONTGOMERY, Associate Professor of Physics, Yale University. 937 *pages, illus., $10.00*

The four sections of this book provide a thorough analysis of the methods and apparatus deemed most useful in measuring the properties of microwaves and designing circuits in which they are to be used. A full description of the measurable quantities of microwaves provides sound groundwork for chapters which deal with sources of power suitable for measuring purposes and the means for detecting energy at microwave frequencies. Methods for measuring wave lengths, impedance, frequency, and attenuation are fully described.

PULSE GENERATORS

Vol. 5. G. N. GLASOE, Rensselaer Polytechnic Institute; and J. V. LEVACQZ, Johns Hopkins Univ., *737 pages, $9.00*

This detailed discussion of the techniques of pulse generation presents a comprehensive survey of the rapid advancements made in this field. It covers the theoretical and practical aspects of the generation of power pulses, the practical methods of pulse-generator design, including hard-tube pulsers, line-type pulsers, and pulse transformers. Pulse powers in the range of 100 watts to 20 megawatts and pulse durations from .03 to 10 microseconds are considered, covering pulse formation, pulse power, circuit efficiency, etc.

MICROWAVE RECEIVERS

Vol. 23. Edited by S. N. VAN VOORHIS, Assoc. Professor of Physics, Univ. of Rochester. 617 *pages, illus., $8.00*

This analysis of wide-band receivers provides a thorough description of the various component circuits and equipment—individual circuit types, duplexers, microwave mixers, local oscillators, automatic frequency control systems, i-f input circuits, amplifiers, and detectors. With this comprehensive groundwork, the book takes up the assembly, testing, and maintenance of receivers, offering analyses of actual receivers which contain examples of important circuit combinations.

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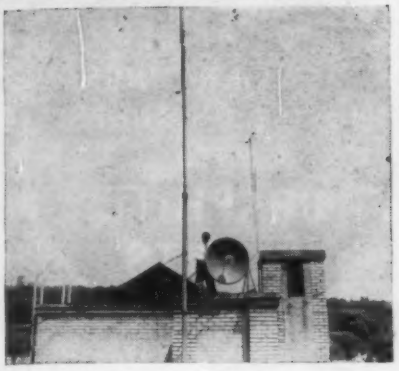

Studio-to-transmitter microwave antenna which beams programs from Ithaca studio to Connecticut Hill transmitter site for rebroadcast over Rural Radio Network

receive from, are: WSLB, Ogdensburg on 106.1 mc, and 75 miles from WVBN, Turin, on 107.7 mc and 72 miles from WVCV, Cherry Valley on 101.9 mc and 56 miles from WVCN, De Ruyter on 105.1 mc.

Each station in the net has a 250-watt GE f-m broadcast transmitter with effective radiated power of 1,300 watts. A trailer is used extensively for on the spot broadcasts, thus making any pasture in the state a broadcast point. This jeep-drawn unit has a 50-watt transmitter operating on 152.75 mc, either from an a-c line or its own 3-kw gas engine-driven generator. A 40-foot collapsible antenna on the trailer provides dependable relaying up to 50 miles to the nearest RRN station, where the remote pickup is picked up and rebroadcast for the network.

Headquarters for the statewide chain are at Ithaca, N. Y. From this point a GE studio-to-transmitter link operating on 940.5 mc beams programs to a transmitter

Engineers adjust antennas of Nemo trailer used by Rural Radio Network for remote pickups. The program is broadcast from here on 152.75 mc to the nearest RRN station

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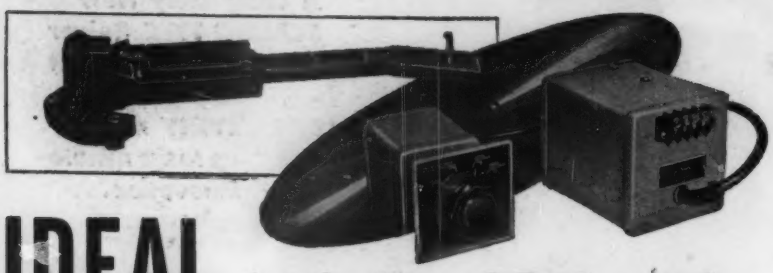

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The GRAY TRANSCRIPTION ARM 103-LP, with Selected GE Variable Reductance Cartridge with 1 mil Diamond Stylus, has been especially designed for use with the new LP Micro-Groove Records. Due to such features as **adjustable stylus pressure, frictionless motion, self-leveling base** and **the accommodation of any standard cartridge,** arm obsolescence is precluded. Arm, with 1 mil Diamond Stylus Cartridge, $77.95.

The GRAY #601 4-position EQUALIZER for GE Cartridge, finest performance and workmanship, ideal response curves. Adopted by radio networks. Matches pickup to microphone channel. Complete, $49.50.

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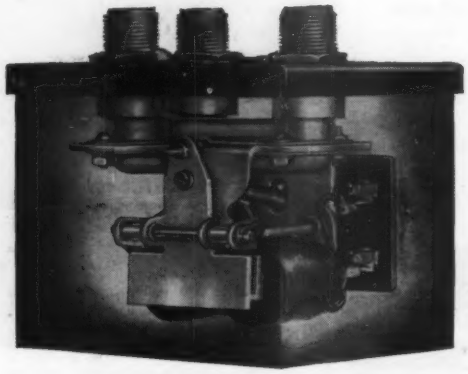

Double coil electro-magnets provide increased power for extra high contact pressures, insuring positive contact under vibration conditions.

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Contact arm construction provides wiping action in both transmit and receive positions.

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Graphite anode tubes are widely used for diathermy, ultra-high frequency, short wave and FM transmitters; for motor control, electrostatic precipitation, resistance welding, electronic heating, counting and sorting. When you buy tubes, ask for the one with the graphite "heart."

4592

SPEER

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site at Connecticut Hill, 9½ miles southwest. There the programs are put on the air and picked up simultaneously by master receivers at other stations, for immediate rebroadcast on their own channels. Each station can also originate programs for pickup by others in the network.

Certificates of Merit

AT CEREMONIES held in several regions recently, presidential certificates of merit were awarded as testimonials for outstanding service in technological research and development during World War II.

The following were the recipients:

Henry B. Abajian of L. H. Terpening Co.; George W. Bailey of the IRE; Wilmer L. Barrow of Sperry Gyroscope Co.; H. H. Benning of Aircraft Radio Corp.; Harold H. Beverage of RCA; K. C. Black of Aircraft Radio Corp.; Hendrik W. Bode and Ralph Bown of Bell Labs.; Herbert E. Bragg of NDRC; Henri Busignies of Federal Telecommunication Laboratories; John F. Byrne and F. C. Cahill of AIL; Howard A. Chinn of CBS; F. S. Cooper of Haskins Laboratories; Inc.; W. F. Davidson of Consolidated Edison Co.; H. D. Doolittle of Machlett Laboratories; O. S. Duffendack of Philips Laboratories, Inc.; John N. Dyer of AIL; Donald G. Fink, editor-in-chief, ELECTRONICS, E. G. Fubini of AIL; Raymond L. Garman of General Precision Equipment Corp.; B. L. Havens of Watson Scientific Computing Laboratory; L. Grant Hector of Sonotone Corp.; William H. Martin of Bell Labs; James H. Moore of AT&T; Haraden Pratt of American Cable and Radio Corp.; J. C. Schelleng of Bell Labs; William P. Short of Federal Telecommunication Laboratories; Hector R. Skifter of AIL; Ernst Weber of Polytechnic Institute of Brooklyn; Browder J. Thompson (posthumously), Vladimir K. Zworykin, Loren F. Jones and Hugh H. Spencer of RCA.

Australian Mobile F-M

FIRST INSTALLATIONS of mobile f-m equipment for public works and police authorities in Australia were recently completed by Amalgamated Wireless (Australasia) Ltd. and Philips' Australian branch plant. Regular f-m entertainment programs, however, are at least a year away.

Train Television

A SUCCESSFUL demonstration of television reception aboard a moving train was made during the recent World Series by Bendix Radio Division of Bendix Aviation and the Baltimore and Ohio Railroad, along the Washington-New York route. Only when the train

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INSTRUMENT DIVISION

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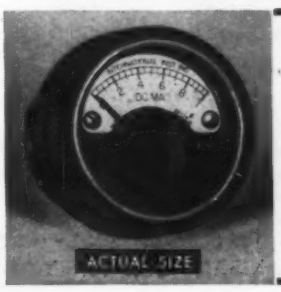
INCORPORATED

The fine quality midget meters formerly manufactured by the MB Manufacturing Company are now being produced by International Instruments, Inc., — a new name for the established line of midget meters of unexcelled accuracy.

Improvements in design have been effected under International Instruments' modern engineering methods. Production has been increased without loss of precision. Now International Instruments can provide prompt delivery of a complete line of improved midget electrical panel meters, ranging from 1" to 1½" in diameter, combining with small size the same ruggedness and accuracy of the larger panel meters.

Production quantities or sample orders are available for practically every use where small size and minimum weight are prime factors. Our engineers will gladly work on adapting International midget electrical instruments to your requirements.

Write now for our new midget meter folder complete with specifications.



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Accuracy — Speed — Simplicity
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AUDIO ENGINEERS:

Note This Report From Langevin

"The Langevin Manufacturing Corporation Development Laboratories finds the Z-Angle Meter extremely useful in the determination of transformer impedances. In the manufacture of amplifiers it is often necessary to determine the impedances existing within amplifier stages. Heretofore, these determinations have involved a long drawn out test procedure. The Z-Angle Meter, however, allows readings to be made accurately and quickly."

Their engineers say, ". . . the plate impedance of a resistance coupled triode tube can be determined by taking a reading with the Z-Angle Meter at the output terminals and then extracting the unknown from the mathematical formula for the impedances in parallel. This is only one of the many uses we have found for this instrument."

THE Z-ANGLE METER is a modern, self-contained instrument for making quick, accurate measurements of **IMPEDANCE** and **PHASE ANGLE** at audio frequencies.

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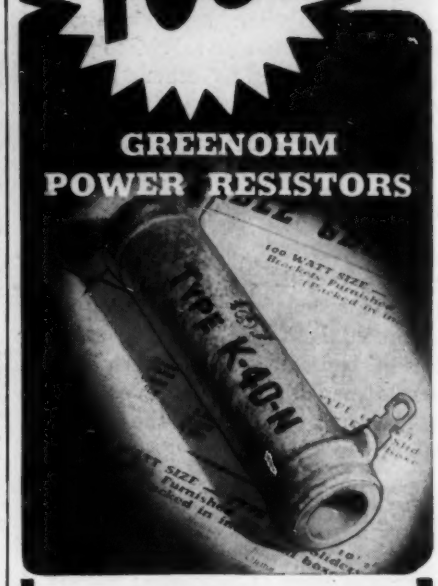
TOUGH!

GREENOHM POWER RESISTORS



★ Yes, TOUGH! Greenohms (made by Clarostat exclusively) are found in radio-electronic and electrical assemblies that simply MUST stand the gaff.

These green-colored power resistors handle heavy overloads without flinching. The exclusive cold-setting inorganic cement coatings means that the wire winding remains unimpaired in manufacture. Coating withstands the heat shock of frequent on-off operation without cracking, flaking, peeling. Yes, TOUGH!

Fixed and adjustable. 5 to 200 watt ratings. Widest choice of terminals and mountings.

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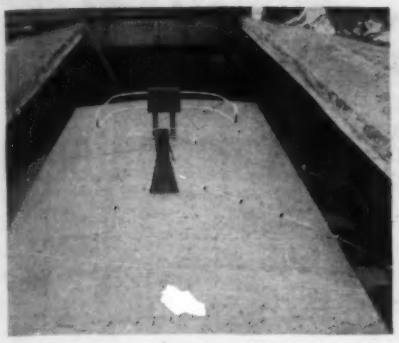


Special antenna mounted atop roof of train for television reception must not extend more than 15¾ inches because of railroad's clearance pattern. Larger portion is used for the 54 to 88-mc band; smaller antenna is for 174 to 216 mc

passed under bridges or steel structures or was out of range of transmitters was there any indication that the receiver was operating under unusual circumstances.

A special antenna known as a ram's horn doublet was mounted atop the car. The a-c power necessary for the set's operation was obtained by using a standard Bendix train radio inverter.

RMA Mobilization Plan

To SPREAD the military preparedness production load broadly throughout the radio industry, the RMA industry mobilization policy committee has presented a plan to the Munitions Board. Aim of the plan is to create as many prime contractors as possible and get the industry as a whole back into government business. The new committee has as its chairman Fred R. Lack of Western Electric Co.

Included in the detailed recommendations is the proposal that the government appoint a four-man committee consisting of three military officers and a representative of industry to properly coordinate and channel current procurement. It was also recommended that the government appoint an industry advisory committee to act as consultants and technical advisors to the four-man procurement committee.

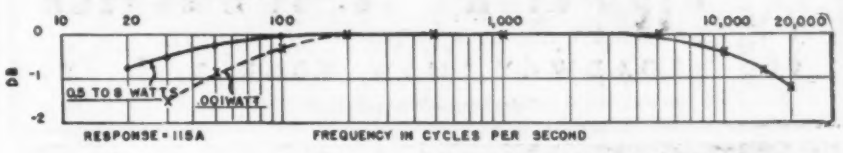
Radiation Detection Display

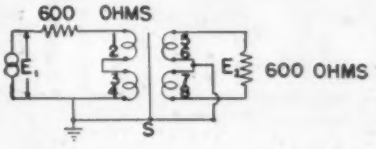
INSTRUMENTS FOR radiation detection in the industrial, medical and biological applications of nuclear

1st LINE PERFORMANCE *Proved in* ADC 2nd Line Transformer

An **ADC** 115A (Industrial Series) impedance matching transformer, picked at random from stock, was submitted to tests to compare its performance with that of other makes of *1st line* transformers. Here are the results. Compare performance of the **ADC** transformer with that of other makes.

FREQUENCY RESPONSE

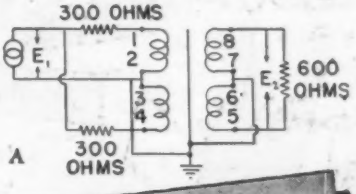




It may be noted that altho the permeability of magnetic materials drops at low flux densities, the **ADC** transformer has sufficient reserve inductance to allow for this even at low power levels. At 40 db below maximum power level it exceeds the response guarantee. Insertion loss at 1,000 cps was 0.75 db

LONGITUDINAL BALANCE

The most common interference voltages encountered in telephone line transmission are longitudinal; that is, the induced voltages in both wires are in phase with respect to ground. These can be removed from the signal voltage only by means of a well balanced line transformer. Illustration "A" shows the test circuit used to measure the degree of removal of these interference voltages. Level reduction on the **ADC** 115A transformer was 67 db at 100 cps and 56 db at 10,000 cps.



CONSULT ADC for your engineered transformer where exacting specifications require positive results. ADC's policy assures you the finest available materials and workmanship to give you the very best electronic components.

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Finest transformer made. For AM and FM broadcast stations and recording studios. ± ½ db 30-15,000 cps.

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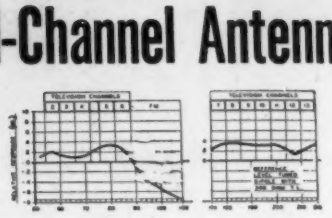
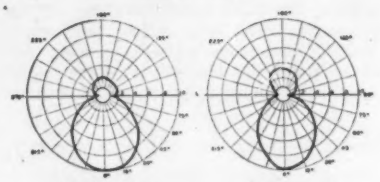


MEGACYCLES



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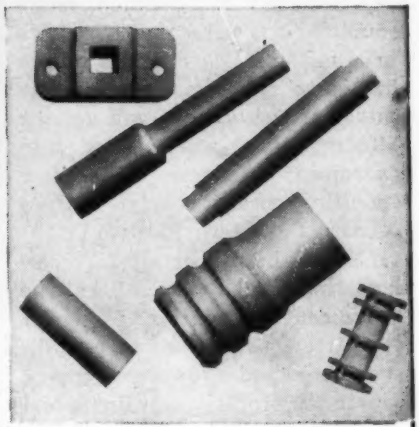

Design engineers and manufacturers in the radio, electrical and electronic fields are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

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energy are being given a comprehensive display at a conference on electronic instrumentation in nucleonics and medicine in New York, November 29 through December 1. The Atomic Energy Commision's exhibit will include 22 types of basic instruments manufactured by 20 commercial companies.

The purpose of the conference is to show the problems facing utilization of atomic energy and the need for cooperation among electronic engineers, physical scientists and medical doctors. Over twenty papers are being presented by various authorities in the atomic energy research and development field.

South American Television

TRANSMITTING EQUIPMENT for South America's first television station was recently sold by General Electric Co. to Cesar Ladeira, one of the founders of Radio Televisao do Brazil. Television service, expected to be functioning within a year, will be operated in collaboration with Radio Mayrink Veiga, PRA-9, of Rio de Janeiro.

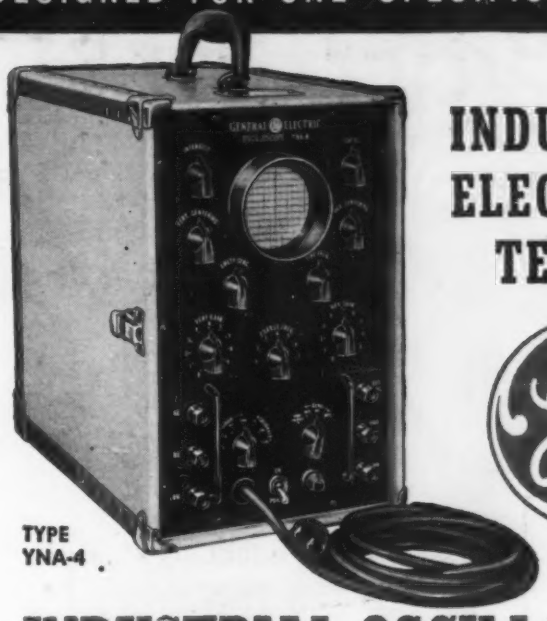
The transmitter will have 5-kw power rating, which will make it comparable in strength to stations operating now in the U. S. The system will operate on American standards of 525 lines, 30 frames and 60 fields in black and white.

The laboratory includes a high-voltage section, a pilot plant, a chemical and metallurgical area, and a photo-technical department.

Technical Information Committee

A SPECIAL COMMITTEE on Technical Information has been formed by Vannevar Bush, chairman of the Research and Development Board, to promote effective exchange of research and development information among the departments of the National Military Establishment. Detlev W. Bronk, president of Johns Hopkins University, is chairman of the new group. Other members include: John E. Burchard, Dean of Humanities, MIT; Herman Henkle, director of the

DESIGNED FOR ONE SPECIFIC PURPOSE—



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INDUSTRIAL ELECTRONIC TESTING

INDUSTRIAL OSCILLOSCOPE

Check—Measure—Test—with the G-E Industrial Oscilloscope.

The following partial list of uses will indicate its importance where ever electrical apparatus is employed.

For checking welding equipment, testing photo-electric circuits, checking performance of relay contacts, performance of high power rectifier tubes, measuring voltage and current relationship in motors, performance of commutators, checking audio oscillators—the YNA-4 Industrial Oscilloscope performs all these important checking and testing functions most efficiently.

D-C Amplifiers for Horizontal and Vertical Deflection—Give a true trace combining both the AC and DC components important for industrial purposes which is not possible with the ordinary oscilloscope used in radio work.

Completely Insulated Case—Since the entire unit is insulated, it may be operated as high as 550 volts above ground. Instrument may be placed on metal working surfaces, machinery, and other advantageous working spots even when connected to ungrounded circuits.

Internal Calibrating Voltages—The YNA-4 provides internal calibrating voltages of known value to enable the operator to set the deflection sensitivity of the oscilloscope. Functions as a vacuum tube voltmeter permitting AC and DC voltage measurements without a voltmeter.

Flexible Input Circuits—Vertical Amplifier—varied inputs are available to accommodate a wide range of voltages and circuit requirements. This oscilloscope may be used to examine voltages from 1.0 volt to 500 volts and its input impedance may be switched from 1 megohm to 10 megohms or to open grid.

Horizontal Amplifier—direct coupled input terminals are provided or the built-in sweep generator may be used for horizontal deflection. This generator may be synchronized with the power line, the vertical amplifier or with an external source.

Wide Sweep Frequency Range—The YNA-4 has been designed so that the operator can observe separate cycles over a wide band of frequencies. A minimum sweep rate of 10 cycles has been established as desirable for industrial operations—this has been incorporated in YNA-4.

For complete information on the YNA-4 Industrial Oscilloscope and other precision measuring equipments write today to: *General Electric Company, Electronics Park, Syracuse, New York.*

165-G4

GENERAL ELECTRIC

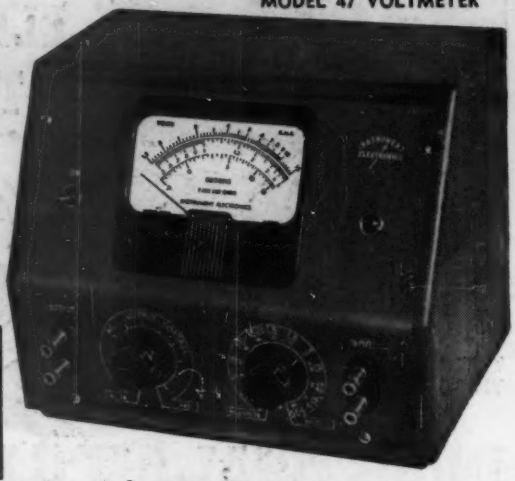
High Sensitivity . . . Logarithmic

AC VOLTMETER

50 MICROVOLTS TO 500 VOLTS

SELF-CONTAINED
ALL AC OPERATED UNIT

MODEL 47 VOLTMETER



An extremely sensitive amplifier type instrument that serves simultaneously as a voltmeter and high gain amplifier.

- Accuracy ±2% from 15 cycles to 30 kc. ±5% from 30 kc. to 100 kc.
- Input Impedance 1 megohm plus 15 uuf. shunt capacity.
- Amplifier Gain 40000

Also MODEL 45
WIDE BAND
VOLTMETER
.0005 to 500 Volts!
5 Cycles 1600 kc.

A few of the many uses:

- Output indicator for microphones of all types.
- Low level phonograph pickups.
- Acceleration and other vibration measuring pickups.
- Sound level measurements.
- Gain and frequency measurements for all types of audio equipment.
- Densitometric measurements in photography and film production.
- Light flux measurements in conjunction with photocells.

Write for Complete Information

Instrument Electronics

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DOUGLASTON, L. I., N. Y.

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We Make
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For The
Manufacture
Of Incandescent Lamps
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TRANSFORMERS OF ALL TYPES

For
LIGHTING
POWER
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PHASE
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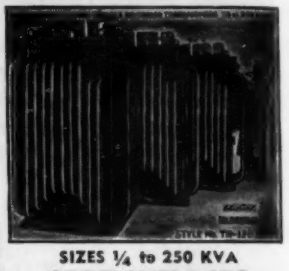
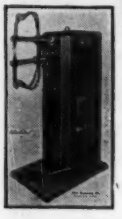
Air, Oil,
or Water
Cooled





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FOR ALL PURPOSES
SIZES ¼ to 250 KVA
Butt Welders - Gun Welders
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Neon Sign Units
Fluorescent Tube
Manufacturing Equipment

CHAS. EISLER

EISLER ENGINEERING CO., INC.

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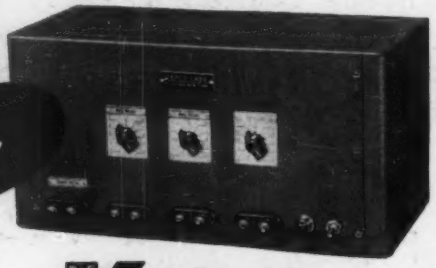
Separate voltage supplies eliminated



Kepco MULTIPLE POWER SUPPLY

CHECK THESE FEATURES

Two continuously variable B supplies, from 0 to 300 volts at currents up to 120 ma.

One continuously variable C supply, from minus 50 to plus 50 volts at 5 ma.

One heater supply, 6.3 volts A. C. at 5 amperes.

Power requirements: 105 to 125 volts, 50 to 60 cycles.

Two 5Y3 rectifiers, two 6Y6 control tubes.

Length 16", height 8", depth 8¾". Wgt. 28 lbs.

ADVANTAGES

Four commonly used voltages from a single compact unit.

B supplies cannot be burned out even if terminals are shorted.

Control circuit eliminates the use of heavy duty power potential dividers.

Complete voltage control from the front panel.

All connections made to sturdy front panel binding posts.

Voltages are isolated from the chassis.

The Kepco Multiple Power Supply is now widely used in schools and industrial laboratories.

Kepco ELECTRONIC INSTRUMENTS

For complete details Address Dept. K-E

Kepco Laboratories, Inc.

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John Crerar Library; Lt. Col. F. L. Walker, Jr., Army; Capt. W. H. Leahy, Navy; and Col. Bernard A. Schriever, Air Force. Norman T. Ball is executive director.

No Change in Operator License Rules

LAST YEAR'S PROPOSAL to provide for three classes of radio operator licenses has been abandoned by the FCC. The Commission finds no justification for the proposed rules or for any substantial changes in present rules, provided that qualifying examinations are kept up to date in relation to developments in the broadcast radio art through appropriate periodic revisions.

British TV System to Stay

TO PREVENT THE SETS now in use from becoming obsolete, the British Broadcasting Corporation's television advisory committee has advised the Postmaster General to make no technical changes which would involve a change in the present television system.

The London television station will continue to operate for a number of years on the present 405-line system. The same system is being adopted for the Midlands station and is proposed for other British stations. Frequencies for vision and sound will be in the neighborhood of 60 mc. Alternative radio and cable links are being provided to make television available to more of the population.

BUSINESS NEWS

RADIO CORP. OF AMERICA and its subsidiaries have been granted a license under the radar development patents owned by Raytheon Mfg. Co., Waltham, Mass.

NUCLEAR INSTRUMENT CHEMICAL CORP. is the new name of Instrument Development Laboratories, Inc., Chicago, Ill. Products include instruments for nuclear and radioactivity measurement.

RANSBURG ELECTRO-COATING CORP., Indianapolis, Ind., has available a

Standardize on One
CAATC
1R2-1
Now, one crystal unit will accommodate all aircraft communications equipment applications. The RH-7B-68 crystal unit is available for commercial airline radio over a frequency range of 1 to 75 mc. This unit, too, can be made to Army-Navy specifications or to fit your particular application. Why not standardize now, on one!
For complete information write for Bulletin RHC-X
REEVES R H HOFFMAN
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CHERRY AND NORTH STREETS • CARLISLE, PA.

Uniformity

The days of "file and fit" went out when volume methods came in. The modern assembly line in large production plants is in itself so dramatically arresting a spectacle that the "feeder lines", of which there are hundreds in every volume industry, are lost sight of. Just as mighty rivers exist only because of the less majestic tributaries, so the production line is dependent upon sources of supply so unvarying in flow and quality, that every part is ready and right to "fall into place" with mechanical precision and constant supply. Our production line has been standardized to a degree of uniformity attainable only through long-time development of machines, controls and skilled workmen.

MACALLEN MICA

A product developed for big business through serving the needs and keeping the pace of big business. Obviously best to help small business grow bigger.

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ALL FORMS, ALL QUANTITIES — ALL DEPENDABLE

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16-mm film covering their electrostatic detearing and spray finishing processes.

CLAROSTAT MFG. CO., INC., has moved from Brooklyn, N. Y., to a block-long plant in Dover, N. H., providing over 250,000 sq ft of floor space to expand operations and add various radio-electronic specialties to its line.

WESTERN ELECTRIC CO., INC., rerently opened a new plant on a 50-acre tract two miles east of Allentown, Pa., for the manufacture of tubes and other precision electronic

Administration building (left) and manufacturing building of Western Electric's Allentown plant

equipment. Cost of the plant, which will employ about 2,500 people, is estimated at over $10,000,000.

MEKELEK, INC., Highland Mills, N. Y., was recently organized for the production of electronic devices, particularly sound apparatus.

WORLD INDUSTRIES, INC., Dayton, Ohio, has been incorporated to manufacture electronic and other products and to operate research and development laboratories.

LENNOX INDUSTRIES, INC., Cleveland, Ohio, has been incorporated for the manufacture of electronic devices.

FAIRCHILD RECORDING EQUIPMENT CORP., New York, N. Y., was recently formed to combine the manufacture and sale of a new magnetic tape recorder with Fairchild Camera and Instrument Corporation's line of recording and sound equipment.

STROMBERG-CARLSON CO. recently broke ground atop Pinnacle Hill, Rochester, N. Y., for television station WHTM. The tower will also be able to support two f-m antennas

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RUBYFLUID

Soldering Flux

Send for Ruby's $1 Offer

For $1 Ruby will send you 1 pint of liquid, one half pound of paste soldering flux and a new booklet on "How to Solder."

Take advantage of this offer now!

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These active patents apply to SYNCHRON Motors, printed on every motor which leaves our factory:

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2,128,141	2,237,960	2,295,786
2,128,142	2,237,961	2,304,688
2,143,653	2,237,962	2,305,963
2,155,266	2,256,711	2,323,035
2,202,693	2,274,957	2,332,634
2,219,388	2,289,495	2,349,620
2,237,958	2,298,373	

May we suggest that if you need timing motors, let us build them for you. We make them in large quantities—at prices difficult to duplicate—and you can avoid costly patent litigation and development expense. Catalog and engineering data on SYNCHRON Timing Motors, Time Machines, and Clock Movements will be mailed promptly on request.

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Established 1907—A Pioneer In Synchronous Motors

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STAINLESS STEEL - LOCKING TYPE
TUBE CLAMPS

Stainless Steel — Corrosion Proof

83 VARIATIONS

Where vibration is a problem, Birtcher Locking TUBE CLAMPS offer a foolproof, practical solution. Recommended for all types of tubes and similar plug-in components.

More than three million of these clamps in use.

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Send for samples of Birtcher stainless steel tube clamps and our standard catalog listing tube base types, recommended clamp designs, and price list.

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COUNT TEN TIMES FASTER ...and accurately!

MODEL 310
ILLUSERATED
PRICE $185.00

The new Photo-electronic Counter was designed for industrial applications in which mechanical counters do not count accurately or wear rapidly because of counting speed. One of the well-known Potter electronic counter decades is used to scale down the operating speed of a reliable electro-mechanical register. In the Model 310, the photo-electric "eye" is located inside the cabinet and the light enters through a small window at the rear. In the Model 312, the photo-electric "eye" is housed separately for remote counting. Small objects as well as closely spaced parts can be accurately counted since the width of the photo-electric beam is only ¼ inch, and does not require complete interruption for actuation. Another version, the Model 311, uses an electromagnetic pick-up coil for counting shaft rotation without contact.

For complete literature or consultation on high speed counting, timing and control problems call or write Dept. 6-S.

NEW POTTER
PHOTO-ELECTRONIC COUNTER

★ High speed—counts at rates up to 6000 per minute
★ Long life—mechanical register operates at only 1/10 normal rate
★ Direct reading—units digit is read from electronic counter, other digits from mechanical counter
★ Accurate—mechanical register not affected by detector "on-off" time
★ Compact — completely self-contained, no wiring required, easy to install
★ Flexible—self-contained "eye", separate "eye" or electromagnetic pick-up coil may be used for actuation

POTTER INSTRUMENT COMPANY
INCORPORATED
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INSTRUMENT Potter COMPANY

Designed for

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Application

The No. 90711

Variable Frequency Oscillator

The No. 90711 is a complete transmitter control unit with 6SK7 temperature-compensated, electron coupled oscillator of exceptional stability and low drift, a 6SK7 broad-band buffer or frequency doubler, a 6A67 tuned amplifier which tracks with the oscillator tuning, and a regulated power supply. Output sufficient to drive an 807 is available on 160, 80 and 40 meters and reduced output is available on 20 meters. Close frequency setting is obtained by means of the vernier control arm at the right of the dial. Since the output is isolated from the oscillator by two stages, zero frequency shift occurs when the output load is varied from open circuit to short circuit. The entire unit is unusually solidly built so that no frequency shift occurs due to vibration. The keying is clean and free from all annoying chirp, quick drift, jump, and similar difficulties often encountered in keying variable frequency oscillators.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY

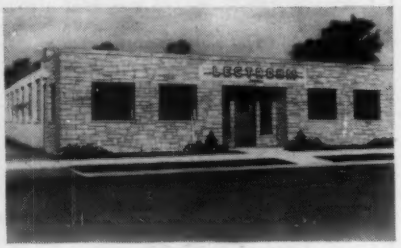
MALDEN

MASSACHUSETTS

M

and two more television antennas. Since Rochester is allotted three channels it is expected that future licensees will take advantage of Stromberg-Carlson's offer to share the tower, so that residents may angle their receiver antennas at one location for a choice of three programs.

LECTROHM, INC., Chicago, Ill., has moved to larger quarters at 5939 Archer Ave. in that city, to increase



New Lectrohm plant

production of vitreous enamel resistors and electric solder pots.

GENERAL ELECTRIC RESEARCH LABORATORY has built its fourth betatron, a 50-million volt device for producing high-energy x-rays for use in cancer treatment.

PERSONNEL

LELAND J. HAWORTH, associated with the Brookhaven National Laboratory since August 1947, has been promoted from acting director to director of this atomic research center. During the war he served with the MIT Radiation Laboratory in radar development.

NEWBERN SMITH, a member of the National Bureau of Standards staff since 1935, has been appointed chief of the NBS Central Radio Propagation Laboratory.

HAROLD P. KNAUSS has resigned as director of research and development at the Mound Laboratory, Miamisburg, Ohio, to become head of the department of physics at the University of Connecticut. During the war he worked on submarine detection at Harvard Underwater Sound Lab and at Submarine Signal Co.

TIMOTHY E. SHEA, after 28 years with Western Electric's engineer-

Speedy Accurate Testing

1. Resistance Testing

LIMIT BRIDGES

For high speed testing of resistors, coils, heater elements and similar products in production quantities where costs must be minimized. Designed for use by non-skilled operators, they are capable of checking as many as 2000 items per hour. Ranges from 1 ohm to 10 megohms. Simple and sturdy, these instruments will withstand hard usage for many years. Described in Bulletin 100.

2. Shorted-Turn Testing

COIL TESTERS

For detecting shorted turns or opens in coil windings of nearly every variety. Speeds of 2000 items per hour easily attained with non-skilled personnel. Will readily detect a single shorted turn of No. 44 copper wire. Operation at 60 cycles assures substantial freedom from capacity effects. Simple and sturdy for long service under hard usage. By detecting defective windings at negligible cost before assembly into completed units, these instruments greatly increase production efficiency and contribute to product quality. Described in Bulletin 109.

★Other Rubicon Products:

Wheatstone, Kelvin and Mueller Bridges; Potentiometers for precise measurement of DC voltages; Galvanometers; Photo-electric Colorimeters; Sanford-Bennett High H Permeameters; Magnetometers for intercomparing permanent magnets. Literature on request.

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- Transformers and components both stock and to specification.

Send for Descriptive Literature

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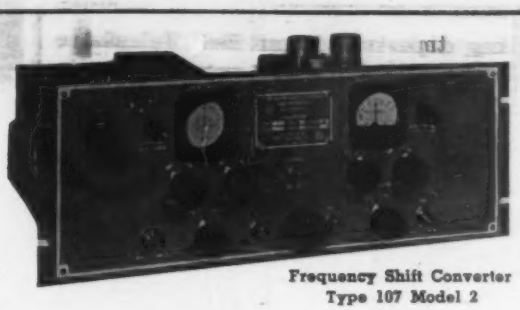
55 Nassau Ave. Brooklyn 22, N. Y.



Frequency Shift Converter
Type 107 Model 2

FOR TELETYPE RECEPTION

Converts any receiver with B. F. O. into teletype operation. Has dual input and combining feature for diversity reception. Audio frequency type. Dual channel ganged discriminator. Provided with demodulator facilities for CW-ICW. Over 60 DB limiting and special discrimination for maximum signal to noise ratio. Tolerates receiver or transmitter frequency drifts of ± 400 cycles in 850 cycle FS operation. Also available with linear output for facsimile.

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NEW and novel tuning and monitoring feature on 2" scope allows tuning of signal either in standby or while keying, which makes tune up a matter of seconds.

FOR OTHER FREQUENCY SHIFT TERMINAL EQUIPMENT SEE OUR ADVERTISEMENT PAGE #190-191 ELECTRONICS BUYERS GUIDE.

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BETA HIGH VOLTAGE POWER SUPPLIES

PROBLEM: A group of research physicists associated with a major photographic equipment supply manufacturing company required a 0-40 KV DC *reversible polarity* power supply. Low ripple was essential.

BETA *Built it!*

MAJOR SPECIFICATIONS
Input: 115 volts, 50/60 cycles; 200 volt-amperes.
Output: 0-40 KV DC; Variac controlled. Either positive or negative polarity as desired.
Output Current: More than 200 μa at 40 KV.
Less than 1% ripple.
Size: 21" x 16" x 48"
Insulation: Air insulation throughout.

Power Supplies up to 200,000 volts DC. regulated or unregulated, built to specifications. Compactness, low cost and rapid delivery featured. *Submit your high voltage power supply requirements to us for a prompt bid on price and delivery.*

Other BETA products include:
KILOVOLTMETERS up to 50 KV.
PORTABLE 0-30 KV DC POWER SUPPLIES.
ELECTRONIC MICROAMMETERS — 0.01 μa full-scale.

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Field engineers throughout the country are at your service to discuss our products more thoroughly with you.

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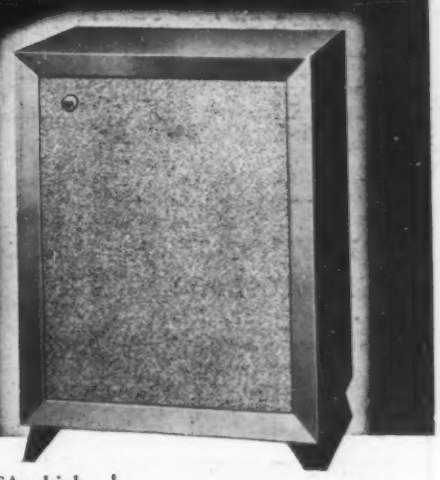
RCA
presents the
LC-4B

Acoustically engineered to give the finest in listening pleasure at the lowest cost.



● From the laboratories and factory of RCA which have produced the speaker equipment now used in some of the world's largest and finest theatres, auditoriums, and studios comes a NEW Console Reproducer—the LC-4B. This unit combines the exceptional frequency characteristics of a unique, low distortion, low frequency speaker and a brilliant, high efficiency, horn type tweeter in a functionally designed cabinet with natural or walnut finish. You can now realize the full tonal range, richness, and color of FM Radio and wide range recordings at a new low price.

SPECIFICATIONS LC-4B
Frequency range 60 to 13,000 cycles
Sensitivity 94 db (Measured with 1MV signal at 4 ft.) Impedance 7.5 ohms
Power Handling Capacity 10 watts.
Weight 44 lbs.
Suggested list LC-4B, Complete $163.50

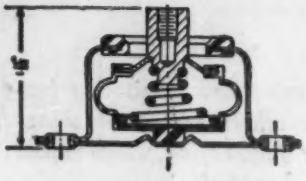
SPECIFICATIONS LC-4A
Frequency range 75 to 13,000 cycles
Sensitivity 97 db (Measured with 1MV signal at 4 ft.) Impedance 7.5 ohms
Power Handling Capacity 20 watts.
Weight 44 lbs.
Suggested list LC-4A, Complete $161.00

Make the RCA Sound Products Distributors in your territory YOUR SOUND HEADQUARTERS.

SOUND PRODUCTS
RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N. J.

In Canada: RCA VICTOR Company Limited, Montreal

New Design Vibration Isolator with Air Damping



BARRYMOUNT TYPE 770 INSTRUMENT VIBRATION ISOLATOR

Revolutionary new design utilizing air damping to limit excursion at resonance. Metalic non-linear springs give constant resonant frequencies throughout a two to one load range. Unaffected by high or low temperatures. For all types of light weight instruments and other applications where a high degree of isolation is required.

Catalog Number	Load Range in Pounds
770-2	1 to 2
770-3	1½ to 3
770-4	2½ to 4½
770-6	3 to 6

Similar type available in larger sizes

BARRYMOUNTS Control VIBRATION and IMPACT

Standard Barrymounts are available for all sizes of mechanical, electrical, and electronic instruments in commercial industrial, and military applications—also an engineering consulting service on special problems.

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ing department and Bell Telephone Laboratories, and most recently assistant engineer of manufacture for Western Electric Co., has been elected president and a director of the Teletype Corp. Early in his career he developed filters and networks used for transatlantic radio, carrier telephony and television. He holds the Medal for Merit and is author of "Transmission Networks and Wave Filters."

T. E. Shea

T. M. Liimatainen

TOIVO M. LIIMATAINEN, formerly associated with Sylvania Electric Products Co., has been appointed to the staff of the Electron Tube Laboratory, National Bureau of Standards, to work on the engineering and development of microwave tubes.

SYDNEY CRAMER, formerly television development engineer with GE, has joined Paramount Pictures television group in the same capacity.

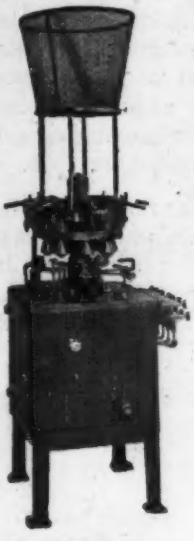
RODNEY D. CHIPP, previously with NBC, has been promoted from assistant chief engineer to director of engineering for the DuMont television network.

H. U. HJERMSTAD, former vice-president in charge of manufacturing and engineering at Federal Enterprises, Inc., has been appointed assistant to the president of Sola Electric Co., Chicago, Ill.

G. LESTER JONES, formerly associated with automatic pilot development at Sperry Gyroscope Co. and prior to that, chief engineer of Sperry Products Co., was recently appointed chief engineer of Lear, Inc., Grand Rapids, Michigan.

HOWARD R. BOYLE, formerly affiliated with Sylvania Electric Products and Sperry Gyroscope Co., has been appointed chief engineer of the key station of the Far East

BAACH-INTERNATIONAL



EIGHT HEAD HOT-CUT FLARE MACHINE

- Automatic throughout.
- Can be synchronized with automatic Stem machine.
- Cuts off and flares in one operation.
- Production 1250 flares per hour. For miniature flares, fluorescent starters, standard size lamps, fluorescent and radio tubes.

RANGE OF MACHINE

Glass tubing
27 to 45 gauge

Length of flares
5 mm. to 80 mm.

Forms flares up to 47 mm. diam.

Net weight, 960 lbs.
Gross weight 1450 lbs.

Dimensions
24"x24"x72" high

INTERNATIONAL MACHINE WORKS

Manufacturers of High Vacuum Pumps, Automatic Machinery for Incandescent Lamps, Electronic Tubes since 1916.

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TEKTRONIX ANNOUNCES...

Tektronix Type 512 Cathode Ray Oscilloscope

THE TYPE 512 DIRECT COUPLED OSCILLOSCOPE

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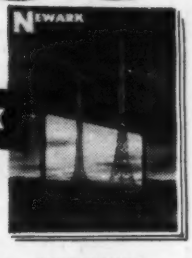

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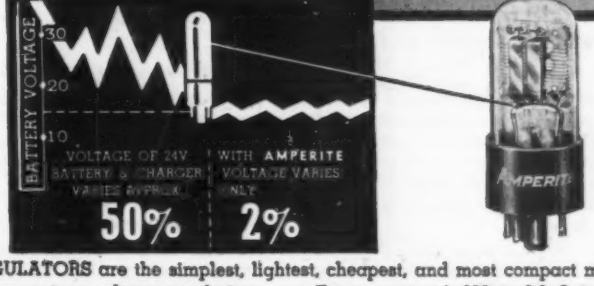

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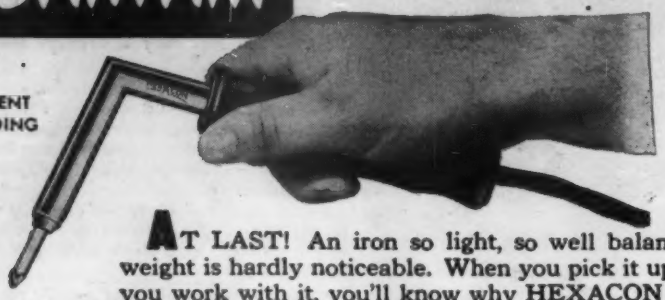

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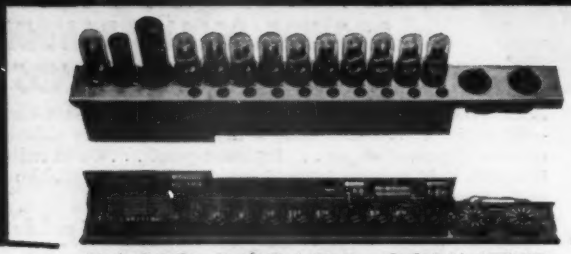

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Network of the Armed Forces Radio Service in Tokyo, Japan.

WILLIAM L. EVERITT, head of the University of Illinois department of electrical engineering since 1944, will become dean of the University's college of engineering and director of its engineering experiment station in September, 1949.

JOSHUA SIEGER, engineering chief of Great Britain's wartime radar program, has been appointed director of research and development of Freed Radio Corp., New York City.

J. Sieger

W. H. Bennett

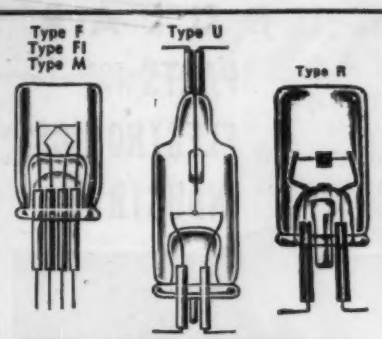
WILLARD H. BENNETT, former director of physical and applied research at the Institute of Textile Technology, was recently named head of the Physical Electronics Section of the Atomic and Molecular Physics Division, National Bureau of Standards. He will engage in basic research on cathode emission processes and the physical properties of negative atomic ions.

RANDALL MCGAVOCK ROBERTSON, formerly research associate of the Norton Co., and associated during the war with the MIT Radiation Laboratory airborne radar group, has been appointed acting director of the Physical Sciences Division of the Office of Naval Research.

CHARLES S. RICH, formerly secretary of the AIEE technical program committee, has been named editor of the Institute's official publications, *Electrical Engineering* and *Transactions*, to succeed G. Ross Henninger who recently resigned.

A. K. WRIGHT, chief radio engineer of the Tungsol Lamp Works, Inc., Bloomfield, N. J., was recently appointed a member of the Joint Electron Tube Engineering Council.

ROBERT FINLAY, wartime procurement engineering counsel for the



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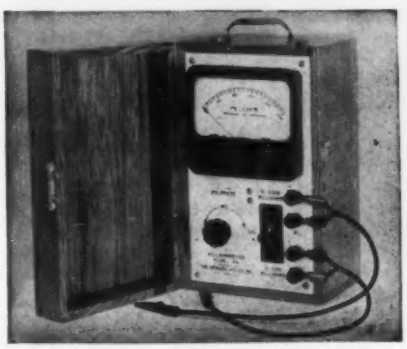

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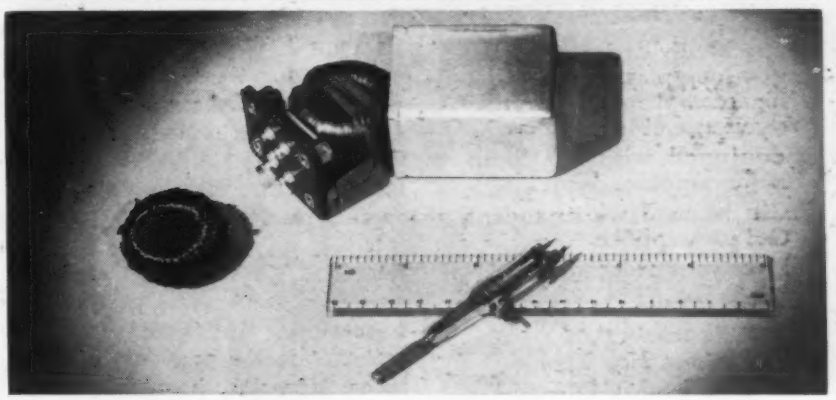

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Hallicrafters Co. in Washington, has opened a consultant's office in Ridgewood, N. J., to serve as liaison between electronics manufacturers and government agencies.

EDWIN F. DILLABY, formerly with Hytron Radio & Electronics Corp., was recently appointed chief engineer in charge of the newly formed Tube Division of Tracerlab, Inc., Boston, Mass.

E. F. Dillaby

F. W. Walker

FRANK W. WALKER, formerly national president of the Associated Police Communications Officers and vice-chairman of Panel 13 of the RTPB, was appointed radio communication engineer in the state of Michigan by Motorola, Inc.

RALEIGH J. WISE, Telefax research engineer for Western Union Telegraph Co., has been awarded the 1948 Longstreth Medal from the Franklin Institute for his development of a dry electrosensitive recording blank.

RALPH A. KRAUSE, senior engineer consultant to Brookhaven National Laboratory, N. Y. and formerly assistant to the president of Raytheon Mfg. Co., has been named director of research at Stanford Research Institute, Stanford University, Calif.

JAY C. FONDA, former engineering consultant, has joined the Morris F. Taylor Co., manufacturers' representatives, as sales engineer.

D. GORDON CLIFFORD, one of the development engineers who worked on the klystron and formerly chief engineer of Industrial & Commerce Electronics, is now field engineer at Lenkurt Electric Co., San Carlos, Calif., manufacturers of carrier telephone and telegraph equipment.

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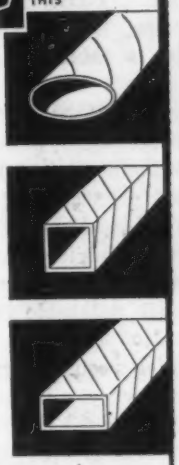

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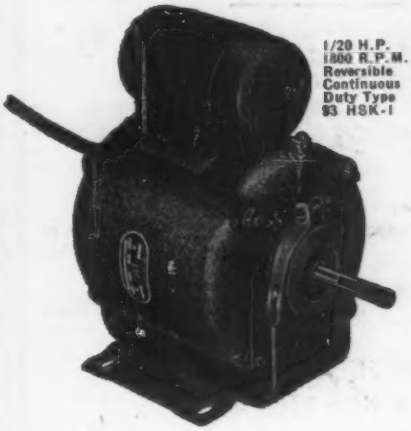

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Frequency Analysis, Modulation, and Noise

By STANFORD GOLDMAN. *McGraw-Hill Book Co., New York*, 1948, 434 *pages*, $6.00.

THIS BOOK is unique in that three virtually unrelated fields are under study. The first, frequency analysis, is obviously stimulated by the author's dissatisfaction with the brevity it usually receives in texts designed to present a variety of mathematical methods at the engineer's level. A total of 140 pages is devoted to the subject; the basic Fourier transforms, in series and integral form, are developed in swift, palatable form, and much attention is given to simplifications which result from various types of symmetry. In addition, a variety of problems is treated to illustrate applications of the Fourier technique, most noteworthy perhaps being those that deal with detail and bandpass requirements in television and pulse receivers.

The portion on modulation is much shorter than the other two, and accordingly not as comprehensive. Instead of attempting a swift course through the entire present status of the art, the author has chosen to organize and expand special items which so far have been treated only in periodical literature. For example, the technique of resolving an arbitrary sideband distribution into symmetrical and antisymmetrical components is treated in some detail, while on the other hand little is said about the means for generating or detecting various modulation types, or about such topics as single sideband, suppressed carrier, and pulsed code.

The final section on noise constitutes the greatest portion of the book, and meets a need long felt by communications engineers who, concerned with noise problems, must refer to the scattered publications of Nyquist, North, Ferris, Schottky and many others. In this book the fundamental contributions of these workers are integrated into a broad, coherent presentation. In an introductory chapter, the author chooses to outline the several types of noise, state the formulas which

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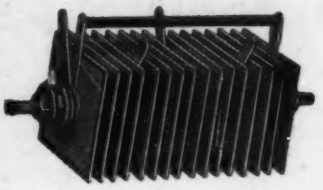

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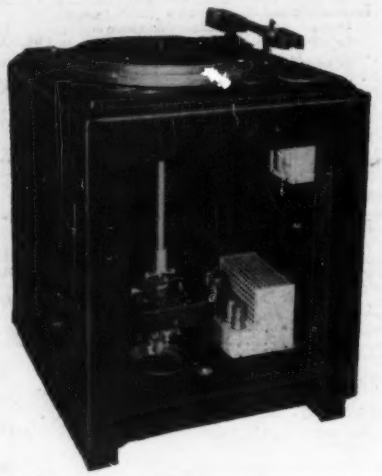

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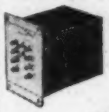

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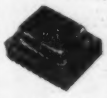

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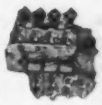

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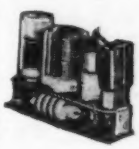

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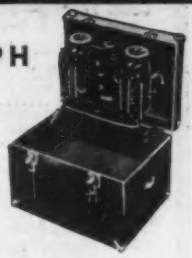

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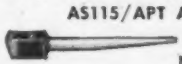

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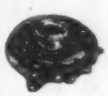

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RECTIFIER TYPE MICROAMMETER, 1.2 VAC Weston 301 3½" Rd fl met case 625 micros sc cal. Power Level Ind.....@ $6.50

TACHOMETER 0-20,000 R.P.M. Port. Chron. type, Jaeger #43A6.....@ $24.50

TACHOMETER 300-1200, 1000-4000, 3000-12000 R.P.M. Mult. Range, Cont. Indicating. Jones Motrola .....@ $24.50

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D.C. VOLTMETER, port. 0-15, 0-150 V. dual range, R.S. steel 6.....$21.00

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803	8.95
804	12.95
805	5.95
806	17.50
807	1.25
808	2.95
809	2.95
810	7.95
811	2.45
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838	3.95
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843	.69
845	4.95
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849A	60.00
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851	$75.00
852	14.95
860	3.00
861	49.95
864	.69
865	2.98
866A	.99
866JR	1.25
868	1.95
869B	75.00
872A	2.95
874	2.49
876	.98
878	2.49
879	.89
884	1.49
885	.98
902P1	7.95
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905	11.95
920	2.95
923	.98
931A	4.95
950	1.06
953B	4.95
954	.75
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991	.69
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0A2	1.69
0A3/VR75	.98
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0B2	2.05
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0C3/VR105	.75
0D3/VR150	.75
OY4	.88
0Z4	.88
0Z4G	.88
1A	.50
1A3	.72
1A4	1.28
1A4P	1.56
1A5GT	.72
1A6	1.28
1A7GT	.80
1B3GT	1.49
1B4	1.56
1B5/25S	1.28
1C5GT	.88
1C6	1.28
1C7G	1.28
1D5GP	1.55
1D7G	1.28
1D8GT	1.56
1E7G	1.56
1F4	1.06
1F5G	1.06
1F6	1.56
1F7G	1.56
1G4GT	1.06
1G6GT	1.06
1H4G	.88
1H5GT	.66
1H6G	1.28
1H6GT	1.28
1J6GT	1.28
1L4	.80
1LA4	1.06
1LA6	1.06
1LB4	1.06
1LC5	1.06
1LC6	1.06
1LD5	1.06
1LF3	1.06
1LG5	1.06
1LH4	1.06
1LN5	1.06
1N5GT	.80
1P5GT	1.06
1Q5GT	1.06
1R4	1.06
1R5	.80
1S4	$ .96
1S5	.72
1T4	.72
1T5GT	1.06
1U4	.80
1U5	.72
1V	.88
2A3	1.28
2A4G	1.28
2A5	.88
2A6	1.06
2A7	1.06
2E5	.88
2V3G	1.98
2X2A	1.25
3A4	.39
3A5	1.39
3A8GT	1.98
3B7	.36
3D6	.36
3Q4	.88
3Q5GT	.96
3S4	.80
3V4	.80
5AZ4	.50
5R4GY	1.15
5T4	1.28
5U4G	.60
5V4G	.96
5W4	1.06
5W4GT	.66
5X4G	.72
5Y3GT	.42
5Y4G	.60
5Z3	.72
5Z4	1.06
6A3	1.28
6A6	1.06
6A7	.80
6A8	.80
6A8GT	.80
6AB7/1853	1.06
6AC5GT	1.16
6AC7/1852	1.16
6AD7G	1.28
6AG5	1.06
6AG7	1.28
6AH6	3.90
6AJ5	.99
6AK5	1.56
6AK6	.96
6AL5	.80
6AL7GT	1.06
6AQ5	.80
6AQ6	.72
6AQ7GT	.88
6AR5	.66
6AS5	.80
6AT6	.60
6AU6	.80
6AV6	.60
6B4G	1.28
6B5	1.56
6B6G	.88
6B7	1.28
6B8	1.28
6B8G	1.28
6BA6	.80
6BE6	.72
6BG6G	1.92
6BJ6	.80
6C4	.39
6C5	.66
6C5GT	.66
6C6	.80
6C8G	1.28
6D6	.66
6D8G	1.28
6E5	.85
6F5	.66
6F5GT	.66
6F6	.80
6F6GT	.66
6F7	1.06
6F8G	1.28
6G6G	1.06
6H6	.60
6H6GT	.60
6J5	.54
6J5GT	.54
6J6	1.16
6J7	.80
6J7GT	.80
6J8G	1.28
6K5GT	.96
6K6GT	.60
6K7	.66
6K7GT	.66
6K8	.96
6K8GT	.96
6L5G	1.06
6L6	1.42
6L6G	1.16
6L6GA	1.16
6L7	.96
6L7G	1.16
6N6G	1.56
6N7	.96
6N7GT	.96
6P5GT	.96
6Q6G/6T7G	$1.06
6Q7	.80
6Q7GT	.72
6R7	1.06
6R7GT	1.06
6S7	1.28
6S7G	1.28
6S8GT	1.06
6SA7	.66
6SA7GT	.66
6SF7	.72
6SD7GT	.49
6SF5	.66
6SF5GT	.72
6SH7	.80
6SH7GT	.80
6SJ7	.66
6SJ7GT	.66
6SK7	.66
6SK7GT	.66
6SL7GT	.96
6SN7GT	.88
6SQ7	.60
6SQ7GT	.60
6SR7	.72
6SR7GT	.72
6SS7	.66
6SV7	.88
6U5/6G5	.72
6U7G	.72
6V6	1.28
6V6GT	.80
6W7G	.88
6X4	.60
6X5GT	.60
6Y6G	.96
6ZY5G	.88
7A4/XXL	.72
7A5	.72
7A6	.72
7A7	.72
7A8	.72
7AD7	1.06
7AF7	.72
7AG7	.88
7AH7	.88
7B4	.72
7B5	.72
7B6	.72
7B7	.72
7B8	.72
7C4/1203A	.39
7C5	.72
7C6	.72
7C7	.88
7E5/1201	1.06
7E6	.72
7E7	.88
7F7	.88
7F8	1.06
7G7/1232	1.06
7H7	.80
7J7	1.06
7K7	1.06
7L7	.88
7N7	.88
7Q7	.72
7R7	.88
7S7	1.06
7V7	1.06
7W7	1.06
7X7/XXFM	1.06
7Y4	.72
7Z4	.72
10	.69
12A	.60
12A6	.39
12A6GT	.39
12A7	1.28
12A8GT	.80
12AH7GT	.88
12AL5	.80
12AT6	.60
12AT7	1.06
12AU6	.80
12AU7	.96
12BA6	.72
12BE6	.72
12C8	.39
12F5GT	.72
12H6	.39
12J5GT	.39
12J7G	.80
12J7GT	.80
12K7GT	.66
12K8	.88
12K8GT	.96
12O7GT	.72
12SA7	.66
12SA7GT	.66
12SC7	.72
12SF5	.80
12SF5GT	.80
12SF7	.80
12SF7GT	.80
12SG7	.72
12SH7	.39
12SJ7	.66
12SJ7GT	.66
12SK7	$ .66
12SK7GT	.66
12SL7GT	.88
12SN7GT	.80
12SQ7	.60
12SQ7GT	.60
12SR7	.39
12SR7GT	.39
12X3	.98
12Z3	.88
14A7/12B7	.88
14AF7/XXD	.88
14B6	.88
14B8	.88
14C5	.88
14C7	.88
14E6	.72
14E7	.88
14F7	.88
14F8	1.06
14H7	.88
14J7	1.06
14N7	1.06
14Q7	.88
14R7	.88
14S7	1.06
14W7	1.06
14X7	1.06
14X4	.88
14Y4	.88
19	1.28
19T8	1.06
22	1.28
24A	.88
25AC5GT	1.16
25A7GT	1.16
25L6GT	.66
25Y5	1.16
25Z5	.60
25Z6GT	.60
26	.72
27	.60
28D7	.39
30	.39
31	.39
32	1.28
32L7GT	1.28
33	.39
34	.39
35/51	.80
35A5	.72
35B5	.80
35L6GT	.66
35W4	.46
35Y4	.72
35Z3	.72
35Z4GT	.60
35Z5GT	.50
36	.39
37	.39
38	.39
39/44	.39
41	.66
42	.66
43	.66
45	.66
45Z5GT	.72
46	1.06
47	.96
50	1.56
50A5	.88
50B5	.66
50L6GT	.66
50Y6GT	.72
53	1.06
56	.72
57	.80
58	.80
70L7GT	1.56
71A	.80
75	.66
76	.66
77	.66
78	.66
79	.88
80	.46
81	1.56
82	1.06
83	1.06
83V	1.28
84/6Z4	.72
85	.88
89	.72
89Y	.39
117L7GT	1.56
117M7GT	1.56
117N7GT	1.56
117P7GT	1.56
117Z3	.60
117Z4GT	1.16
117Z6GT	.96
FM-1000	1.28
1273	.88
9001	.89
9002	.39
9003	.69
9004	.49
9005	.98
9006	.49

(ALL TUBE TYPES IN STOCK NOW—SUBJECT TO PRIOR SALE—PRICES SUBJECT TO CHANGE WITHOUT NOTICE)

20% DEPOSIT WITH ORDERS UNLESS RATED

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160 GREENWICH STREET — NEW YORK 6, N. Y.

Phone Dlgby 9-1132-3-4

All Prices F.O.B. N. Y. C.

NEW GUARANTEED SURPLUS

AUTOSYNS

Pioneer
AY-1, AY-14, AY-20, AY-30, AY-54, AY-101D, etc.

Prices on Request

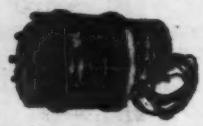
SYNCHROS

Navy Types

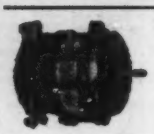
1G, 1F, 1CT, 5G, 5F, 5CT, 5DG, 5HCT, 5SF, 5HSF, etc.

Prices on request

SELSYN SPECIAL



W.E. KS-5950-L2. Size 5. 115 v. 400 cycles. Use on reduced 60 cycles. Stock #SA-182. **Price $3.75 each**



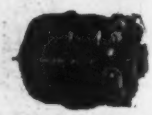
Kollsman 775-01 Selsyn

Ideal for Ham use as transmitter or receiver. 6-12 volts 60 cycles. 26 volts 400 cycles. Stock #SA-57. **Price $3.75 each**

Phase Shift Capacitor — 4 stators single rotor 0-360° phase shift. (Use in complex wave synthesis.) Stock #SA-114. **Price $4.75 each**

DYNAMOTOR

D-101. 27 v. DC in @ 1.5 amps. DC output 285 v. @ .060 amps. Stock #SA-187. **Price $1.50 each.**



RATE GENERATORS

Elinco PM-2

2.0 v. DC per 100 rpm. Use to 2000 rpm. Stock #SA-53. **Price $7.50 ea.**

ELINCO F-16. 2 Phase AC. 1.3 v. AC per 100 rpm. 60 cy. output at 1800 rpm. Stock #SA-193. **Price $12.50 each.**

SWEEP GENERATOR CAPACITOR

Hi-speed bearings. Split stator. Silver plated coaxial type. 5-10 mmf.

Stock #SA-167. **Price $2.75 each.**

INVERTER SPECIALS

400 Cycles

Three Phase

Holtzer Cabot MG-153—Input 28 volts DC at 52 amps. Output three phase 115 volts 400 cycles at 750 V.A. 0.90 P.F. Also second output of 26 volts 400 cycles at 250 V.A. Voltage and frequency regulated. Stock #SA-134.

Price $99.50 each

Leland SD-93—(10258)—Input 28 volts DC at 60 amps. Output 115 volts three phase 400 cycles at 750 V.A. 0.90 P.F. Second output voltage of 26 volts 400 cycles at 50 V.A. Voltage and frequency regulated. Designed for use with various autopilots. Stock #SA-209.

Price $79.50 each

SPERRY PHASE ADAPTOR — 661102 115 volts 400 cy. Used for operating 3 phase equipment from single phase source. Stock #SA-194. **Price $6.75 each.**

Quotations on request for the following inverters.

General Electric 5AS131JJ11A—(PE-218)
Navy Type CRV-21AAR G.E. 5AS121LJ2
General Electric 5D21NJ3A
Holtzer Cabot MG-149H
Holtzer Cabot MG-149F
Wincharger PU7/AP
Wincharger MG-750
Pioneer 12123-1A
Pioneer 12117-2
Pioneer 12117-5

ALSO IN STOCK

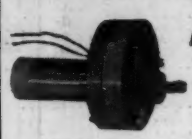
SINUSOIDAL POTENTIOMETERS
SINE COSINE GENERATORS
(Diehl Types FJE-43-9 and FPE-43-1)
PIONEER TORQUE UNITS
KOLLSMAN COMPASS SYSTEMS
AIRCRAFT TACHOMETER SYSTEMS
AMPLIDYNES - MAGNESYNS
DC SERVO MOTORS
SERVO AMPLIFIERS
GYROS - AUTOPILOTS

LP-21-LM Compass Loops

New — Original Cartons

Stock #SA-99.

Price $9.50 each.



G.E. 10 RPM DC Motor 5BA 10FJ12

Output 40 lb. in at 10 rpm. 24 V. @ 1.1 amps. Series-wound. 2 wire reversible.

(Frame is common wire.)
Ideal for relay servo-systems. Stock #SA-17. **Price $8.75 each.**

Delco PM Motor—5068571

Alnico field. 27 v. DC. 10,000 rpm. 1" x 1" x 2". 0.120 diam. shaft. 31/64" lg. Stock #SA-151. **Price $3.75 each.**

12V D.C. Motor John Oster B-9-2

1.4 amps.
5600 rpm.

1¾" Diam. x 3¾" Lg. Spline shaft. C. W. rotation. Stock #SA-46. **Price $3.75 each.**

Blower Assembly MX-215/APG

John Oster C-2P-1L

28 V. DC. 7000 RPM. 1/100 H.P. #2 L-R Blower.

Stock #SA-202. **Price $4.00 each**

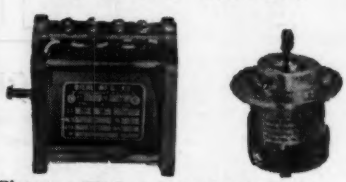
BEAM ROTATOR

1 rpm. 12 v. DC or 40 v 60 cy. operation. Reversible. 3½" diam. 5" lg. ½" diam. spline shaft. Ideal for Ham or television antennas. Stock #SA-185.

Price $9.50 each.

Synchron 10 RPM Timing Motor—24 V. DC. Stock #SA-110. **Price $3.75 each.**

AC SERVO MOTORS



Pioneer—CK-2 and 10047-2A for 400 cy.
Kollsman—776-01 for 400 cycles.
Diehl—FP-25-3, **FPE-25-11** (CDA-211052) and ZP-105-14 for 60 cycles.

Prices on Request

110 RPM MOTOR

G.E. 5BA10J18D, 27 V. @ 0.7 amps, 1 oz/ft. torque. 1⅝" diam. x 3½" lg. Operates on AC or DC. Stock #SA-98.

Include 15¢ for P.P. and handling

Price $2.95 ea. net

TWX Pat-199.

Write for complete listing, or call ARmory 4-3366

SERVO-TEK PRODUCTS CO.
Incorporated
Surplus Division

Open account shipments to rated concerns.

All prices F.O.B. Paterson, N. J.

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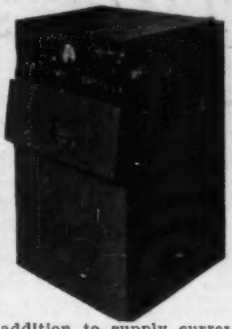
Raytheon RECTICHARGERS

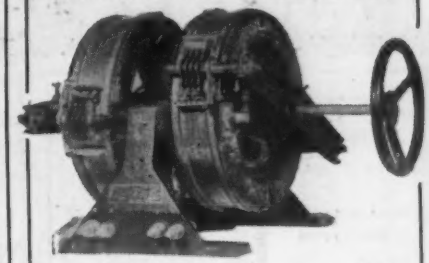


Input: 115 volts AC, 60 cy., 1 Ph. . . . Output: 48 v. DC at 3 amperes regulated and adjustable. Charges 23 to 24 cell battery or may be used direct as battery eliminator.

The Raytheon Recticharger is designed to supply current at constant voltage to any load within its rating, and in addition to supply current to a storage battery connected across its load, of sufficient amount to maintain full charge. The function of the battery is to supply surge current due to sudden changes in load and to supply current above the rating of the Recticharger for temporary overload, and to act as a "stand-by" source of power in event of commercial power failure.

BRAND NEW $69.50

TRANSTAT VOLTAGE REGULATOR



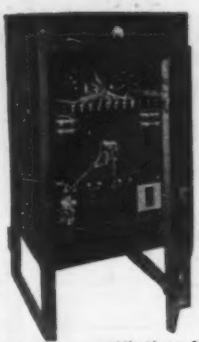
Max KVA Output.....11.5
Single Phase.....50-60 Cycles
Fixed Winding.....115 Volts
Commutator Range.....0-115 Volts
Max. Amperage 100
With reconnection for 220 V. Operation: Max Amperage.....50

This Transtat has wide application to control temperature, motor speed, illumination, rectifier output, filament supply, voltage compensation, instrument calibration, and general testing and laboratory use.

Net weight 134 Lbs. Dim. 25" W x 16" D x 17½" H (Exclusive 8" shaft extension)

Brand New $75.00

GE BATTERY CHARGER



Input. 115 V, 60 cy., 1 Ph. .....

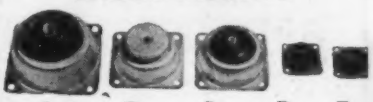
Output. Charges 54 cell battery at from 1 to 10 ampere rate.

Complete with spare fan and fuses. Brand new in original packing cases. Shipping wt. approx. 305 lbs.

The model 6 RC 89F16 Copper Oxide Battery Charger consists of a transformer, a secondary reactor, a copper oxide rectifying element, a ventilating fan, control circuits and auxiliary equipment necessary for proper operation. Transformer tapped for various supply voltage. Eight secondary taps for adjusting charging rate.

BRAND NEW $149.50

SHOCK MOUNTS



	A	B	C	D	E
A. Lord #20, 3" x 3" x 1¾"					.40
B. U. S. Rubber #5150 C 2⅜" x 2⅜" x 1⅛"					.30
C. Lord #15 2⅜" x 2⅜" x 1⅛"					.25
D. Lord #10 1⅛" x 1⅛" x ⅝"					.10
E. Lord #3 1⅛" x 1⅛" x ⅝"					.10

BRAND NEW

LINEAR SAWTOOTH POTENTIOMETER

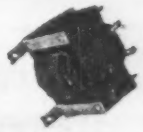
W.E. No. KS 15138

The d-c potentiometer consists of a closed type die-cast aluminum alloy frame consisting of a continuous resistance winding to which electric power is supplied through two fixed taps 180 degrees apart. Two rotating brushes (180 degrees apart and bearing on the resistance winding) and two take-off brushes are provided for the output voltage. Varying the position of the brushes varies the output voltage in accordance with a linear sawtooth wave. The potentiometer is excited with 24-volt direct current, is arranged for panel or bracket mounting, is approximately 3-11/16 inches in diameter, 3 inches deep, 4⅝ inches long, and has an approximate weight of one pound. External connections are made through a standard AN type connector.

Brand New $5.75

STEPDOWN TRANSFORMERS

Input: 115V.-60 cycles.
Output: 20 V., at 10 amps. Also tapped at 6V., for pilot light. Ideal for Selenium Rectifier Applications, etc.



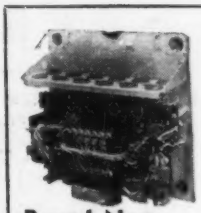
Brand New $2.45

SELENIUM RECTIFIER

Bridge Type

Input: 36 V. AC.
Output: 28 V. DC., 1.1 Amps.

Brand New $2.75



400 CYCLE SERVO AMPLIFIER

G. E. Type 2CV1C1

Brand New $29.50

METER SHUNTS

10 Amp. 50 Mv.

BRAND NEW $ .50

SOUND POWERED TELEPHONE HANDSETS

W. E. Type TS-10M.
Complete with 7 ft. cord.

Brand New . . . $16.95

PARABOLOIDS

Ideal for microwave experimental work.
Spun Magnesium dishes
Reinforced Perimeter
17½" Diameter x 4" Deep
Two sets mounting brackets on rear.
Open center hole 1½" x 1⅜"

Per Pair, Brand New . . . $8.75

MERCURY CONTACT RELAY

Western Electric D-168479

For applications in all types of high speed switching devices. Long service life, high operating speeds. Large current and voltage handling capacity, uniform and constant operating characteristics under adverse atmospheric conditions. Hermetically-sealed mercury-wetted contacts in gas-filled glass envelope. Free from moisture, dirt, corrosion and atmospheric pressure. Single pole double throw contacts.

1000 hours life at 60 operations per second. Two coils of 700 ohms, and 3300 ohms. Operating current, coils series aiding—6.6 mils. Release current, coils series aiding—5.2 mils. Four page Technical Data on request.

Brand New in Original Cartons, $4.75

DYNAMOTORS—500 Watt

Navy Type CAJO-211444

Input: 105-130 Volts D.C., 6 amps. Output 13 or 26 Volts D.C. (26 V. at 20 amps. in series of 13 V. at 40 amps. in parallel). Designed for radio use, fully R.F. filtered, complete with separate Square D line switch box.

BRAND NEW $59.50

RADAR ANTENNAS

SO-1 (10 cm.).....$149.50
SO-13 (10 cm.).....$129.00
TDY (10 cm.).....$95.00

Radar Repeater Adapters, Antenna Control units with P P I units, Transmitter-Receiver units, etc. for SO Radar.

All Brand New Equipment.

ACME HI-VOLT TRANSFORMERS

Primary: 115 V., 60 cycles.
Secondary: 8000 V., C.T., 800 V.A.

Brand new in sealed cans $27.50

MOTOR GENERATORS

Brand New War Surplus Machines Built by Allis Chalmers Co. to U. S. Navy Specifications.

Input: 115V. D.C. at 14 amps., 3600 rpm.
Output: 120V A.C., 60 CY. 1 ph. at 10.4 amps. 1000 Watts continuous duty. Ball bearings.
Splashproof. Fully enclosed. Centrifugal starter.
Frequency adjustable to load.
Length 26"; Width 12⅞"; Height 13".

Price $97.50

Same machine but for 230V. D. C. input.

Price $125.00

Prices FOB, Tuckahoe, N. Y. Subject to Change Without Notice. 20% With Order on C.O.D. Shipments.

ELECTRONICRAFT INC.

All merchandise guaranteed. Immediate delivery, subject to prior sale.

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RELIANCE Wishes its many friends a VERY MERRY CHRISTMAS

RG 8/U NEW-UNUSED 52 OHM COAXIAL CABLE

4¢ A FOOT

500-2,500 feet	$40.00 per M
3,000-5,000 feet	35.00 per M
5,500-10,000 feet	30.00 per M
10,500-20,000 feet	27.50 per M
over 20,000 feet	25.00 per M

No charge for reels.

COAXIAL FITTINGS

Hood 10¢ — Socket 40¢ SO-239 83-1R — Plug 40¢ PL-259 83-1SP — Angle Adaptor 20¢ M-359 83-1AP

PL258A, 83-1SPN, 83-1J, UG21U, UG22U, UG13U, UG27U, UG281 U assembled with short piece of RG 58U ..... 40¢ each
UG85U Baby "N" Plug ..... 40¢ each
UG87U Baby "N" Socket, Gold Plated with Hood Attached ..... 50¢ each

FILAMENT TRANSFORMER

WESTINGHOUSE #6D4298

Tested at 34,000 volts

Pri. 115 V. A.C., Sec. 5V@6.5 Amp.

ONLY $8.50

CHOKES

400 MA. 12 Henry 90 Ohms, 6,000 V.D.C. Test. Hermetically Sealed. 4½" x 5⅝" x 4¼", 12 lb. $3.85

PRECISION RESISTORS

1% OR BETTER

Any Order For

100 pieces.....10% Off

1000 pieces.....20% Off

¼ WATT—25c

6.68	12.32	16.37	123.8	414.3
10.48	13.02	20.	147.5	705
10.54	13.52	62.54	220.4	2193
11.25	13.89	79.81	301.8	10,000
11.74	14.98	105.8	366.6	59,148

½ WATT—25c

.250	11.1	235	4,451	15,000
.334	13.15	260	5,000	15,750
.502	46	270	5,900	17,000
.557	52	298.3	6,500	20,000
.627	55.1	400	7,000	25,000
.76	75	723.1	7,500	30,000
1.01	97.8	2,500	8,000	100,000
1.53	125	2,850	8,500	150,000
2.04	180	3,427	10,000	
2.25	210	4,000	14,825	

1 WATT—30c

1.01	5.21	1,250	9,000	55,000
2.58	10.1	3,300	18,000	65,000
3.39	10.9	5,000	20,000	70,000
5.05	270	7,000	50,000	75,000

1 WATT—40c

100,000	128,000	180,000	470,000	525,000
120,000	130,000	250,000	500,000	600,000
125,000	160,000	320,000	522,000	700,000

1 Megohm, 1W, 1%, 65c, 5%, 40c

MINIMUM ORDER $3

CAPACITORS

OIL FILLED

MFD	V.D.C.	Price	MFD	V.D.C.	Price
.375 @	16,000 and		.2 @ (2,200	750 V.A.C. V.D.C.)	.49
.75 @	8,000	$14.95	10	1,000	1.75
.1	7,500	12.50	8	1,000	1.50
.1	7,500	1.95	4	1,000	1.00
.1-.1	7,000	2.45	3	1,000	.80
.1	7,000	1.85	2	1,000	.65
.02-.02	7,000	1.65	.05	1,000	.29
.1	6,000	1.75	1	800	.40
.03-.03	6,000	1.65	10	600	1.35
1	6,000	8.50	4	600	.69
.01	5,000	1.35	2	600	.39
.25	3,000	1.75	1	500	.29
			.5	500	.24

POSTAGE STAMP MICAS

5mmf	66*mmf	220mmf	525*mmf	.0015mfd
8.2	68	300	560	.002*
10	90	360	650	.0022*
22	100	390*	680*	.0027*
33	110*	400	750	.003*
39	120*	430*	800	.0033*
47	150*	470	820*	.0039*
50	160	488*	.001mfd	.0068*
56	180*	500*	.0012	.01
60	200	510*	.0013*	

* Silver Mica

Price schedule

5MMF to .001MFD	5¢	Silver Mica	10¢
.0012MFD to .0027MFD	7¢	Silver Mica	20¢
.0029MFD to .0068MFD	12¢	Silver Mica	50¢
.0082MFD	16¢	.01MFD	18¢

CERAMIC CONDENSERS— 6c ea.

3.44 mmf	12 mmf	27 mmf	62 mmf	91 mmf
4.7	13	33	68	150
6.8	15	50	75	220
10	22	56	82	1000

$4.50 per 100 of one value.

ELECTROLYTIC

20-20 mfd	450 VDC	self mtg. can	95¢
125	350	self mtg. can	95¢
20	200	can	20¢
10	100	can	15¢
1000	25	self mtg. can	85¢
75	25	threaded can	30¢
40	25	can	20¢
50	25	tubular	15¢
1000	15	self mtg. can	35¢
225	15	self mtg. can	25¢

SMALL VARIABLE AIR

5-25 mmf	7 plates	15¢	3-30	double spaced	30¢
3-50	14 plates	20¢	7-80	21	25¢
5-30	9 plates	29¢	7-1000	27	30¢

CERAMIC VARIABLE

3-12 Erie NPO 25¢ — 4-30 Erie N500 25¢ — 20-120 Centralab 30¢

PULSE TRANSFORMERS

X 143T 2, UTAH, core—⅝" x ⅜" x ¼", 3 windings, open frame, capable of shortest pulses $1.50

X 124 T2, UTAH, marked 9262 or 9280, small gray case 1⅞" high x 1⅛" x ⅝" with two 6-32 mtg. studs. Ratio 1:1:1, hypersil core $1.50

Spec.—10, 111, Chicago Transformer equivalent of 9262 ..... $1.50

134-BW, Westinghouse, core—1½" x ⅜" x ⅞", 4 windings open frame $1.50

7472407, GE, core ⅝" x 1⅝" x 3/16", 2 windings (0.6 ohm and 0.08 ohm DC) $1.25

80G16, GE $1.25

D161310 Western Electric, cased 1⅜" dia. x 1⅞" high, impedance ratio 120 to 2350 ohms, molybdenom Permalloy tape core. Frequency response 50 Kc to 4 Mc $2.00

D166638, Western Electric, cased 1⅜" x 1¼" x 2¼", 2 semitorridal windings, 150 turns ea. of two windings, used in portable oscilloscope $1.25

352-7250-2A, cased 15/16" dia. x 1⅝" high, DC 10 ohm, 3⅓ ohm sine waveresponse 140 cy. to 175 Kc $1.25

352-7251-2A, similar to above but for shorter pulses $1.25

300 KVA GE 7557296, 50 ohm pulse cable connection; 3,850 V. in 17,300 V. out. (250 KVA @ ¼ micro second) $15.00

800 KVA GE 7710417, 50 ohms pulse cable connection, 450 ohm output, 9500 volt input, 28000 volt pk. output, Bifilar $19.50

All Orders f.o.b. PHILA., Pa.

SWITCHES

G/E switchette CR 1070C 123, SPST, N.C. ..... $.20

Micro switch, BZ 2R5, SPDT, small pin ..... 45¢, 10 for $4

Micro switch, YZ RQ1, SPST N.O., push button ..... 45¢, 10 for $4

H&H Toggle, 6A, 125V, SPDT ..... 35¢, 10 for $3

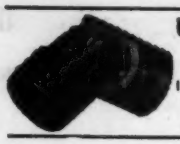
U. S. Instrument Corp., 2 pole 16 position, exceptional quality, dual wiping heavy silver contacts, 2⅛" x 2⅞" x 1½" deep. Single hole mount. Not to be confused with ordinary wafer switch $1.95

Altitude limit switch SA 1A/ARN-1 completely enclosed 2 pole 11 position $1.00

Oak wafer switch, bakelite, 4 pole 5 position non-shorting ..... $.60

H&H, 6 pole double throw, 10 ampere 125 V.A.C. $1.50

UNIVERSAL JOINT



ALUMINUM

1⅛" long x ½" O.D. ¼" ID

35¢

HARDWARE

Glyptal—cement, 1 quart cans GE #1286 ..... $.75

ALLEN SET SCREWS

4-40x1/8	8-32x1/8	10-32x1/4
4-40x3/16	8-32x3/16	1/4-20x1/2
6-32x1/8.	8-32x5/16	1/2-16x3/8
All sizes		$1.50 per C

⅜—32 nuts for potentiometers. **100 for $1.00**

15/32—32 nuts for toggle switches **100 for $1.00**

Screw, Nut & Washer Asst ..... 3 lbs $1.00

Vernier dials, 2⅝" dia. 0-100 in 360°, black with silver marks, thumblock. For BC221 ..... $.85

Hose clamps. Aero seal, QS 100M4—½" nom. dia. or QS 100M8—¾" nom. dia. **50 for $2.50**

SLIP RING ASSEMBLY — 5 silver plated rings on molded bakelite rotor. Stator hold, 2 silver carbon brushes for each ring. Rotor 3⅞" O.D., fits 1¾" shaft. Complete with brushes $2.95

Split lock washers. #2, 4, 6, 8, 10, 12 ..... 95¢ per 1000

Wrapped—BALL BEARINGS—New

Mfg.	ID	OD	Width	Price
Fafnir 33K5E	3/16"	1/2"	5/32"	25¢
Fafnir 38K	5/16"	7/8"	9/32"	45¢
Timken	1/2"	1 3/8"	7/16"	85¢
ND5202C13M	1/2"	1 3/8"	1 3/8" (dual)	1.25
ND 88503	43/64"	1 37/64"	21/32"	1.00
MRC 206SF	1 5/32"	2 7/16"	5/8"	1.25
Fafnir 545	2 1/6"	2 5/8"	15/32"	1.00
ND-R 4A	1/4"	3/4"	7/32"	.35¢

NEEDLE BEARINGS

B88 1/2" wide	1/2"	11/16"	25¢
B108 1/2" wide	5/8"	13/16"	30¢
GB34X 1/4" wide	3/16"	11/32"	25¢

Mounting Brackets—(Bakelite) for selsyns and differentials shown below ..... 25¢ pair

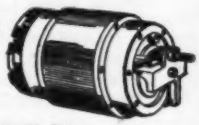
SELSYNS

ONLY $7.25 pair

#C78248

115 V., 60 Cyc., 3¼" dia. x 4½" body. Used in Pairs for Remote Control.
Also 50 V., 50 Cyc., $4.75 pair.

SELSYN DIFFERENTIAL #C78249 ONLY $2.25 ea.



115V., 60 Cyc.
Used between two #C78248's as dampener. Can be converted to a 3600 RPM Motor in 10 Minutes. Conversion sheet supplied.
Also 50 V., 50 Cyc., $1.50 ea.

RELIANCE MERCHANDIZING CO.

Arch St. Cor. Croskey, Philadelphia 3, Pa. *Telephone Rittenhouse 6-4927*

FREE CATALOG

Write today for your copy of our listings of thousands of surplus bargains.

ANNOUNCING!
Greater Values Than Ever Before In Our New Larger Store At 189 Greenwich St.; N. Y. 7 (Come In And Browse Around)

R·H·S
SPECIALS OF THE MONTH

ANNOUNCING!
THE OPENING OF OUR NEW LARGER QUARTERS AT 189 GREENWICH ST., N. Y. 7 (STREET LEVEL STORE)

1 K.W. POWER SUPPLY KIT
2500-0-2500 Volts @ 500 MA
or
2000-0-2000 Volts @ 500 MA
(oil-filled Xformer from BC610) $39.95
1—Swinging choke 14.95
1—Smoothing choke 7.95
1—Filament Xformer 9.95
2—2 Mfd., 3000 v. Condensers, ea 3.45
2—872A Tubes ..... each 1.95
2—Plate Caps for 872A.... each .20
2—Sockets for 872A..... each 1.19
2—Hash Filter Chokes.. pr. .79
All parts New! Reduced to $79.50

SELENIUM RECTIFIERS
Full Wave Bridge Type

INPUT		OUTPUT		
up to 18v AC	up to	12v DC	½ Amp.	$0.98
up to 18v AC	up to	12v DC	1 Amp.	1.95
up to 18v AC	up to	12v DC	5 Amp.	4.45
up to 18v AC	up to	12v DC	10 Amp.	7.45
up to 18v AC	up to	12v DC	15 Amp.	9.95
up to 18v AC	up to	12v DC	30 Amp.	14.95
up to 36v AC	up to	28v DC	1 Amp.	3.45
up to 36v AC	up to	28v DC	5 Amp.	7.45
up to 36v AC	up to	28v DC	10 Amp.	12.45
up to 36v AC	up to	28v DC	15 Amp.	18.95
up to 115v AC	up to	100v DC	.25 Amp.	2.95
up to 115v AC	up to	100v DC	.6 Amp.	6.95
up to 115v AC	up to	100v DC	5 Amp.	19.95
up to 115v AC	up to	100v DC	3 Amp.	12.95

OIL CONDENSERS
NATIONALLY ADVERTISED BRANDS
All Ratings D. C.

2x.1mfd.	600v	$0.35	1mfd.	2000v	$0.95
.25mfd.	600v	.35	2mfd.	2000v	1.75
.5mfd.	600v	.35	4mfd.	2000v	3.75
1mfd.	600v	.35	15mfd.	2000v	4.95
2mfd.	600v	.35	4mfd.	2500v	3.98
4mfd.	600v	.60	2mfd.	2500v	2.49
8mfd.	600v	1.10	.1mfd.	2500v	1.25
10mfd.	600v	1.15	25mfd.	2500v	1.45
3x.1mfd.	1000v	.45	.5mfd.	2500v	1.75
.25mfd.	1000v	.45	05mfd.	3000v	1.95
1mfd.	1000v	.60	.1mfd.	3000v	2.25
2mfd.	1000v	.70	.25mfd.	3000v	2.65
4mfd.	1000v	.90	1mfd.	3000v	3.50
8mfd.	1000v	1.95	12mfd.	3000v	6.95
10mfd.	1000v	2.10	2mfd.	4000v	5.95
15mfd.	1000v	2.25	1mfd.	5000v	4.95
20mfd.	1000v	2.95	.1mfd.	7000v	2.95
24mfd.	1500v	6.95	3mfd.	4000v	6.95
.1mfd.	1750v	.89	2mfd.	3000v	3.45
.1mfd.	2000v	.95	2x.1mfd.	7000v	3.25
.25mfd.	2000v	1.05	.02mfd.	12000v	9.95
.5mfd.	2000v	1.15	.02mfd.	20000v	11.95

HIGH CAPACITY CONDENSERS

10,000 mfd.—25 WVDC	$6.95
2x3500 mfd.—25 WVDC	3.45
2500 mfd.—3 VDC	.39
3000 mfd.—25 WV DC	2.49
2x1250 mfd.—10 VDC	1.25
1000 mfd.—15 WVDC	.99
200 mfd.—35 VDC	.59
100 mfd.—50 WVDC	.49
4x10 mfd.—400 VDC	.89
4000 mfd.—18 WVDC	1.95
4000 mfd.—25 WVDC	2.95
4000 mfd.—30 WVDC	3.25

FILTER CHOKES
HI-VOLTAGE INSULATION

8 hy @ 550 ma	$7.95	325 hy @ 3 ma	$3.45
8 hy @ 300 ma	3.95	1 hy @ 800 ma	14.99
25 hy @ 160 ma	3.49	10 hy @ 250 ma	2.45
12 hy @ 150 ma	2.25	10 hy @ 200 ma	1.98
30 hy @ 70 ma	1.39	10/20 @ 85 ma	1.59
.05 hy @ 15 amps	7.95	15 hy @ 125 ma	1.49
1 hy @ 5 amps	6.95	15 hy @ 100 ma	1.39
4 hy @ 600 ma	5.95	3 hy @ 50 ma	.29
200 hy @ 10 ma	3.49	30 hy Dual @ 20 ma.	1.49
600 hy @ 3 ma.	3.49	8/30 hy @ 250 ma	3.50
065 hy @ 2.5A	2.49	10 hy @ 100 ma	1.29

RADIO TUBES
NEW! STANDARD BRANDS!

1B24	$22.95	726A	$4.50	1LN5	$.79
1B26	4.95	800	1.69	1Q5GT	.95
1B29	.89	801A	.49	1R5	.79
1N21	.59	802	2.95	1S4	.69
1N23	.59	803	5.95	1S5	.59
1N34	1.60	805	3.95	1T4	.59
1P24	.89	807	1.19	3Q4	.59
2AP1	2.39	808	1.95	3Q5	.69
2C22	.19	809	1.98	3S4	.59
2C26	.29	810	6.25	5Y4GT	.49
2C40	.74	811	1.49	6A7	.59
2C44	1.29	812	1.39	6A8GT	.59
2C46	3.75	813	5.25	6AG5	.79
2D21	1.59	814	2.75	6AG7	.98
2J21	12.95	815	1.45	6B4G	.95
2J22	12.95	816	1.10	6BG6G	1.49
2J26	9.95	826	.49	6C6	.49
2J31	14.95	829B	4.85	6D6	.49
2J32	14.75	832A	2.95	6F5GT	.49
2J36	24.95	833A	29.50	6F6GT	.49
2J37	18.95	836	.79	6F6	.59
2J38	14.75	837	1.49	6H6GT	.39
2J39	18.95	838	2.95	6J5GT	.42
2J40	18.95	841	.50	6J5	.55
2J46	18.95	843	.39	6J7GT	.55
2J49	26.95	845	3.29	6K6GT	.49
2J51	69.50	851	17.95	6K7GT	.49
2J54B	18.95	860	1.98	6L6G	.95
2J55	18.95	861	11.95	6L6	1.23
2K25	24.95	865	.79	6L7	.79
2K28	8.95	866A	.85	6Q7GT	.55
2V3G	.79	866JR	1.10	6SA7GT	.49
2X2	.39	869B	28.75	6SC7	.55
3AP1	2.79	874	.69	6SF5GT	.59
3BP1	1.39	876	.39	6SH7	.49
3B22	.59	878	1.89	6SJ7GT	.49
3B24	.69	884	.79	6SK7GT	.49
3B26	1.95	885	.79	6SL7GT	.59
3CP1	2.95	902P1	5.95	6SN7GT	.59
3C22	19.95	905	4.95	6SQ7GT	.49
3C23	2.49	923	.69	6V6GT	.59
3C24	.29	954	.35	6X5GT	.59
3C30	.59	955	.35	7A8	.69
3C31	1.49	956	.45	7B7	.59
3DP1	2.25	957	.35	7C5	.59
3D21A	1.50	958	.35	7C6	.59
3E29	3.39	1611	.98	7F7	.49
4B24	2.25	1613	.58	7Y4	.49
4E27	12.95	1616	.75	12A8GT	.63
5AP4	4.75	1619	.21	12AT6	.49
5BP1	1.10	1622	1.59	12AU6	.75
5BP4	4.95	1624	.85	12BA6	.59
5CP1	2.95	1625	.19	12BE6	.59
5D21	18.95	1626	.25	12J5GT	.49
5FP7	.85	1629	.19	12J7GT	.49
5JP1	11.95	1630	3.95	12K7GT	.49
5J29	18.95	1638	.69	12Q7GT	.59
5J30	18.95	1654	1.98	12SA7GT	.49
5LP1	11.95	1851	.89	12SF5GT	.49
5R4GY	.89	2050	.75	12SF7GT	.59
5T4	.69	2051	.45	12SJ7GT	.49
5U4G	.45	8005	2.29	12SK7GT	.49
5V4	.72	8011	.65	12SQ7GT	.49
5X4	.59	8012	1.98	12SR7GT	.49
5Y3	.35	8013	.89	14A7	.69
5Z3	.55	8014	6.95	14B6	.69
5Z4	.79	8016	1.39	14Q7	.69
6AB7	.95	8020	.89	24A	.49
6AC7	.59	8025	4.89	25L6GT	.49
6AK5	.89	9001	.39	25Z5	.47
6AL5	.59	9002	.35	25Z6GT	.45
6C4	.25	9003	.35	26	.45
6D4	1.29	9004	.29	27	.49
6J4	3.95	9005	.39	30 Spec	.39
6J6	.89	9006	.29	32L7GT	1.19
6Q5G	1.25	CK1005	.29	35/51	.59
7EP4	17.95	CK1006	.69	35A5	.59
10Y	.39	CK1090	1.49	35L6GT	.49
12A6	.25	EF50	.50	35W4	.35
12DP7	13.95	F123A	12.95	35Y4	.69
12GP7	13.95	F127A	17.50	35Z3	.57
15E	.89	F128A	69.50	35Z5GT	.39
15R	.89	F660	39.50	36	.79
75TL	3.49	FG81A	4.75	41	.52
100TH	9.95	FG105	7.95	42	.49
211	.35	FG238B	39.50	43	.52
227A	3.75	GL146	10.95	45	.52
231D	1.49	GL805	39.50	45 Spec	.35
249C	1.75	GL897	29.50	47	.74
250TH	19.49	HY75	1.25	50A5	.89
304TL	.99	HY615	.49	50B5	.59
304TH	3.95	ML100	29.50	50L6GT	.49
316A	.35	ML101	39.50	50Y6GT	.59
327A	4.95	ML502	99.50	56	.54
350B	1.95	VR75	.89	59	.95
368AS	2.95	VR90	.65	70L7GT	1.29
371B	.99	VR105	.65	71A	.59
450TH	29.95	VR150	.65	75	.52
527	8.95	VT127A	2.49	76	.49
531	2.50	VU111	.49	77	.49
550	.75	024	.59	78	.49
703A	2.95	1A5GT	.49	80	.35
705A	1.85	1A7GT	.59	81	1.55
706CV	18.95	1H5GT	.54	82	.89
714AY	6.95	1N5GT	.59	83	.89
715B	8.95	1LA4	.95	83V	.89
715C	18.95	1LA6	.95	84	.59
717A	.59	1LB4	.95	89	.60
721A	.59	1LC6	.95	117L7GT	1.15
723A/B	8.95	1LD5	.95	117P7GT	1.15
724A/B	1.75	1LF3	.95	1172 3	.49
725A	7.45	1LH4	.79	117Z6GT	.69

All Tubes guaranteed, except for open filaments, shorts and broken glass, for which we check before shipment. Please specify how to ship.

500 WATT POWER SUPPLY KIT
(Ideal for BC-191 & BC-375E)
1—Transformer—Pri: 105/250v
60 cyc in 5v Steps
Sec: 1120-0-1120v @ 500 MA
2½v CT @ 10 AMPS
12v @ 14 AMPS
17v @ 2½ AMPS
32v @ .025 AMPS... $32.50
2—Filter Chokes @ $7.95 ea.. 15.90
2—Condensers 3 Mfd @ 2000v DC @ $4.45 ea..... 8.90
2—866 Tubes @ $.89 ea..... 1.78
2—Plate Caps Ceramic @ $.20 ea ..... .40
2—Sockets @ $.20 ea..... .40
1 Pair Hash Filter Chokes..... .79
Extra Special Buy $49.50

TRANSFORMER—115 V. 60 Cy.
HI-VOLTAGE INSULATION

3710v @ 10 ma.; 2x2½v @ 3A	$9.95
2500v @ 15 ma	6.50
2500v @ 4 ma.; 2½v @ 2A. 6.3v @ 1 amp.	7.95
2150v @ 15 ma	5.50
1750v @ 4 ma.; 6.3v @ 3A	6.50
1600v @ 4 ma.; 700v CT @ 150 ma.; 6.3v @ 9A	7.95
525–0–525v @ 60 ma.; 925v @ 10 ma.; 2x5v @ 3A; 6.3v @ 3.6A; 6.3v @ 2A; 6.3v @ 1A	7.95
515–0–515v @ 175 ma.; 5v @ 3A; 2.5v @ 5A	5.95
500–0–500v @ 25 ma.; 262–0–262v @ 55 ma.; 6.3v @ 1A; 2x5v @ 2A	4.49
500–0–500v @ 100 ma.; 5v CT @ 3A	4.95
450–0–450 @ 300 ma, 140–0–140 @ 100 ma. 36v @ 1A, 6.3v @ 5A, 5v @ 3A, 110/220 Dual. Pri.	8.95
425–0–425 @ 200 ma.; 150–0–150 @ 100 ma.; 40v @ 1A; 6.3v @ 5A; 5v @ 3A; 110/ Dual Pri. tapped	7.50
400–315–0–100–315v @ 200 ma.; 2.5v @ 2A; 5v @ 3A; 6.3v @ 9A; 6.3v; 9A	6.50
400–0–400v @ 200 ma.; 5v @ 3A	4.95
350–0–350v @ 150 ma.; 5v @ 3A; 6.3v @ 6A; 78v @ 1A	4.95
385–0–385–550v @ 200 ma.; 2½v @ 2A; 5v @ 3A; 3x6.3v @ 6A—PRI. 110/220	7.95
350–0–350v @ 150 ma.; 5v @ 3A; 6.3v @ 7.5A; 6.3v @ 3A	4.99
350–0–350v @ 35 ma	1.45
340–0–340v @ 300 ma.; 1540v @ 5 ma	5.95
335–0–335v @ 60 ma.; 5v @ 3A; 6.3v @ 2A; 0–13–17–21–23v @ 70 ma.—PRI. 110/220	4.95
325–0–325v @ 120 ma.; 10v @ 5A; 5v @ 7A	3.49
300–0–300v @ 65 ma.; 2x5v @ 2A; 6.3v @ 2½A; 6.3v @ 1A	3.49
250–0–250v @ 100 ma.; 2x6.3v @ 4A; 6.3v @ 5A; 6.3v @ 1A	4.95
150–0–150 @ 80 ma.; 150 @ 40 ma.; 6.3v @ 3.5A; 6.3v @ 1A	1.98
150v @ 55A; 150v @ 2.13A; 5v @ 5A	5.95
120–0–120v @ 50 ma	.98
80–0–80v @ 225 ma.; 5v @ 2A; 5v @ 4A	3.95
24v @ 6A	3.50
3x18v @ 2A	3.95
13.5v CT @ 3.25A	2.95
3x10.3v @ 7A; CT	9.95
12.6v CT @ 10A; 11v CT @ 6.5A	7.95
3x6.3v @ 1A; 2x6.3v @ 2A; 10v CT @ 10A; 12.6v CT @ 1A	4.95
6.3v @ 12A; 6.3v @ 2A; 115v @ 1A	3.95
6.3v @ 10A; 6.3v @ 1A	3.50
6.3v @ 1A; 2½v @ 2A	3.45
5v @ 20A; Dual 110v PRI	3.49
6.3v @ 21½A; 6.3v @ 2A; 2½v @ 2A	5.95
5v—190A ..... $17.50 6.3v @ 1A	.98
5v—115A ..... 14.95 8v CT 1A	.98
2.5v @ 20A ..... 3.49 .6v @ 15ARMS	2.98
6.3v CT @ 3A; 5v CT @ 4A	4.25

All Prices Subject to Change Without Notice
All merchandise guaranteed. Mail orders promptly filled. All prices F.O.B. New York City. Send money order or check. Shipping charges sent C.O.D. Minimum order $5.00. 20% Deposit required with all orders.

RADIO HAM SHACK Inc.
189 GREENWICH ST. NEW YORK 7, N. Y.

SAVE— Brand New and Fully Guaranteed

SYNCHROS

If Special Repeater, 115 volts, 400 cycle. Will operate on 60 cycle at reduced voltage.—**Price $15.00 each net.**

1CT Control Transformer, 90/55 volts, 60 cycle.—**Price $22.50 each net.**

2J1G1 Control Transformer, 57.5/57.5 volts, 400 cycle.—**Price $2.00 each net.**

2J1H1 Selsyn Differential Generator, 57.5/57.5 volts, 400 cycle.—**Price $3.25 each net.**

5G Generator, 115 volts, 60 cycle.—**Price $25.00 each net.**

W. E. KS-5950-L2, Size 5 Generator, 115 volts, 400 cycle.—**Price $3.50 each net.**

Size 5 Generator, Army Ordnance Drawing No. C-78414, 115 volts, 60 cycle.—**Price $14.00 each net.**

PIONEER AUTOSYNS

AY1, 26 volts, 400 cycle.—**Price $4.00 each net.**

AY20, 26 volts, 400 cycle.—**Price $5.50 each net.**

AY30, 26 volts, 400 cycle.—**Price $10.00 each net.**

AY31, 26 volts, 400 cycle. Shaft extends from both ends.—**Price $10.00 each net.**

AY38, 26 volts, 400 cycle. Shaft extends from both ends.—**Price $10.00 each net.**

PIONEER PRECISION AUTOSYNS

AY101D, new with calibration curve. PRICE—WRITE OR CALL FOR SPECIAL QUANTITY PRICES

AY131D, new with calibration curve. —**Price $35.00 each net.**

GENERAL ELECTRIC D. C. SELSYNS

8TJ9-PDN Transmitter, 24 volts.—**Price $3.00 each net.**

8DJ11-PCY Indicator, 24 volts. Dial marked −10° to +65°.—**Price $4.00 each net.**

8DJ11-PCY Indicator, 24 volts. Dial marked 0 to 360°.—**Price $6.50 each net.**

PIONEER TORQUE UNITS

Type 12602-1-A.—**Price $30.00 each net.**

Type 12606-1-A.—**Price $35.00 each net.**

Type 12627-1-A.—**Price $70.00 each net.**

PIONEER TORQUE UNIT AMPLIFIER

Type 12073-1-A.—**Price $17.50 each net.**

RATE GENERATORS

PM2, Electric Indicator Company, .0175 V. per R. P. M.—**Price $7.25 each net.**

F16, Electric Indicator Company, two-phase, 22 V. per phase at 1800 R. P. M.—**Price $12.00 each net.**

B-68, Electric Indicator Company, Drag Cup, 110 volts, 60 cycle, one phase. —**Price $14.00 each net.**

INVERTERS

12117-4, Pioneer. Input 24 volts D. C. Output 26 volts, 400 cycle.—**Price $15.00 each net.**

12117, Pioneer. Input 12 volts D. C. Output 26 volts, 400 cycle.—**Price $15.00 each net.**

12123-1-A, Pioneer. Input 24 volts D. C. Output 115 volts, 400 cycle, 3 phase. Voltage and frequency regulated. 100 V. A.—**Price $75.00 each net.**

153F, Holtzer Cabot. Input 24 volts D. C. Output 26 volts, 400 cycle, 250 V. A., and 115 volts, 400 cycle, 3 phase, 750 V. A. Voltage and frequency regulated.—**Price $150.00 each net.**

WG750, Wincharger, PU16. Input 24 volts D. C. Output 115 volts, 400 cycle, 1 phase, 6.5 amps. Voltage and frequency regulated.—**Price $35.00 each net.**

149H, Holtzer Cabot. Input 28 volts at 44 amps. Output 26 volts at 250 V. A. 400 cycle and 115 volts at 500 V. A. 400 cycle.—**Price $39.00 each net.**

149F, Holtzer Cabot. Input 28 volts at 36 amps. Output 26 volts at 250 V. A. 400 cycle and 115 volts at 500 V. A. 400 cycle.—**Price $29.00 each net.**

SPERRY PHASE ADAPTER

Type 661102, 115 volts, 400 cycle. Used for operating 3 phase equipment from a single phase source.—**Price $6.50 each net.**

SINE-COSINE GENERATORS

(Resolvers)

FJE 43-9, Diehl, 115 volts, 400 cycle. —**Price $20.00 each net.**

D. C. ALNICO FIELD MOTORS

5067127, Delco, 27 V., 250 R. P. M.—**Price $2.90 each net.**

5069600, Delco, 27 V., 250 R. P. M.—**Price $4.00 each net.**

5069466, Delco, 27 V., 10,000 R. P. M. —**Price $3.00 each net.**

WRITE FOR COMPLETE LISTINGS

D. C. MOTORS

5069625, Delco Constant Speed, 27 volts, 120 R. P. M. Built-in reduction gears and governor.—**Price $4.25 each net.**

A-7155, Delco Constant Speed Shunt Motor, 27 volts, 2.4 amps., 3600 R. P. M., 1/30 H. P. Built-in governor.—**Price $6.25 each net.**

5BA10J18D, General Electric, 27 volts, 0.7 amps., 110 R. P. M.—**Price $2.90 each net.**

5066665, Delco Shunt Motor 27 volts, 4000 R. P. M. Reversible, flange mounted.—**Price $4.50 each net.**

C-28P-1A, John Oster Shunt Motor, 27 volts, 0.7 amps., 7000 R. P. M., 1/100 H. P.—**Price $3.75 each net.**

A. C. MOTORS

5071930 Delco, 115 volts, 60 cycle, 7000 R. P. M.—**Price $4.50 each net.**

36228, Hayden Timing Motor, 115 volts, 60 cycle, 1 R. P. M.—**Price $2.85 each net.**

SERVO MOTORS

CK1, Pioneer, 2 phase, 400 cycle.—**Price $10.00 each net.**

CK2, Pioneer, 2 phase, 400 cycle.—**Price $4.50 each net.**

FPE-25-11, Diehl, Low-Inertia, 75 to 115 V., 60 cycle, 2 phase.—**Price $16.00 each net.**

FP-25-2, Diehl, Low-Inertia 20 volts, 60 cycle, 2 phase.—**Price $9.00 each net.**

FP-25-3, Diehl, Low-Inertia 20 volts, 60 cycle, 2 phase.—**Price $9.00 each net.**

GYROS

Schwein Free & Rate Gyro type 45600. Consists of two 28 volt D. C. constant speed gyros. Size 8" x 4.25" x 4.25".—**Price $10.00 each net.**

Schwein Free & Rate Gyro, type 46800. Same as above except later design.—**Price $11.00 each net.**

Sperry A5 Directional Gyro Part No. 656029, 115 volts 400 cycle, 3 phase.—**Price $17.50 each net.**

Sperry A5 Vertical Gyro. Part No. 644841, 115 volts 400 cycle 3 phase.—**Price $20.00 each net.**

Sperry A5 Amplifier Rack Part No. 644890. Contains Weston Frequency Meter. 350 to 450 cycle and 400 cycle, 0 to 130 voltmeter.—**Price $10.00 each net.**

Sperry A5 Control Unit Part No. 644836.—**Price $7.50 each net.**

Sperry A5 Azimuth Follow-Up Amplifier Part No. 656030. With tube. —**Price $5.50 each net.**

Pioneer Type 12800-1-D Gyro Servo Unit. 115 volts 400 cycle, 3 phase. —**Price $15.00 each net.**

Norden Type M7 Vertical Gyro. 26 volts D. C.—**Price $20.00 each net.**

Norden Type M7 Servo Motor. 26 volts D. C. **Price $20.00 each net.**

INSTRUMENT ASSOCIATES

147-57 41st AVENUE Telephone INdependence 3-1919 FLUSHING, N. Y.

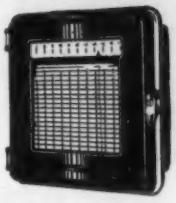
SEARCHLIGHT SECTION

STANDARD D. C. POTENTIOMETER TYPE—MICROMAX

L & N INDICATORS — CONTROLLERS — RECORDERS

Rebuilt . . . Thoroughly re-conditioned . . . Mechanically, electrically checked and adjusted . . . Instruments shipped ready to put into actual use.

Model S INDICATING & RECORDING CONTROLLER



Single Point - Curve Drawing, Continuous Line One set adjustable High & Low contacts 115 V AC Motor-Flush mounted metal case Gasketed door. RANGES: 0-1000° F C/A, 0-1500° F C/A, 0-1800° F C/A, 200-2000° F C/A. 1000-2000° F C/A **$210.00**

Model S—RECORDER—CONTROLLER

H.C.L. Contacts—115 V. AC motor Extra set on-off contacts. Range 0-1500°F C/A **$210.00**

Model R INDICATING & RECORDING CONTROLLER

Single Point-Curve Drawing, Continuous Line Chart speed—one revolution in 24 hours One set Adjustable High & Low Contacts 115 V AC Motor-Flush mounted metal case Gasketed door. RANGES: 0-800° F C/A, 700-1400° F I/C, 200-2000° C/A **$175.00**

Model S INDICATING & RECORDING CONTROLLER

Single Point-Curve Drawing, Continuous Line Two Thermocouple terminal board—Two sets of High-Common-Low contacts for controlling 115 V AC motor. RANGES: 0-1200° F C/A, 0-1800° F C/A..... **$210.00**

Model C SINGLE POINT CONTROLLER

Non Indicating, Non Recording, Open type contacts for use with External relay, High-Common-Low Contacts for controlling, 115 V AC motor, Metal case, gasketed door, flush mount. RANGES: 0-1500° F I/C, 0-1600° F C/A, 0-1800° F C/A, 0-2000° F C/A, 200-2000° F C/A, 800-2000° F C/A..... **$135.00**

MODEL S—RECORDER

with alarm feature using relay & cam operated contacts. Can be used as on-off controller without temperature setting device. 115 V, AC motor, Range 0-1800° F C/A **$210.00**

Model S—RECORDER—CONTROLLER

Single Pen—2 Thermocouples—2 sets H.C.L. Contacts—115 V. AC motor. Ranges F C/A, 0-1800°F C/A..... **$210.00**

SURPLUS BARGAINS — — NOW!!

SELENIUM RECTIFIERS

New—Fresh Stock—Not over 6 mos. old. Full wave bridge . . . single phase . . . resistive inductive load . . . continuously rated . . . conservative design.

Type	Max. R.M.S. Input	Max. D.C. Output at 35° C	Price
5B-1	24	18 V @ 3.1 A	$5.03
5B-1	24	18 V @ 5.2 A	6.73
10B-1	24	18 V @ 10 A	8.71
1B-1	24	19 V @ 1.6 A	4.04
16B-1	24	19 V @ 16 A	16.40
24B-1	24	19 V @ 24 A	23.76
1B-2	48	37 V @ 1.2 A	7.21
3B-2	48	37 V @ 3.1 A	9.60
5B-2	48	37 V @ 5.2 A	13.37
10B-2	48	37 V @ 10 A	17.18
16B-2	48	37 V @ 16 A	30.89
24B-2	48	37 V @ 24 A	44.67
5B-6	144	110 V @ 5.2 A	35.70
2B-6	144	112 V @ 2.4 A	21.86
1B-6	144	114 V @ 1.2 A	17.34
2B-7	168	131 V @ 2.4 A	25.51
1B-7	168	133 V @ 1.2 A	19.68
5B-7	168	133 V @ 5.2 A	41.10

RECTIFIER TRANSFORMERS

PRI—105/110/115/120 V.—50/60 Cycles—Open Frame Construction

SEC—18 V @ 2.5 Amps	4 lbs.	$3.35
18 V @ 5 Amps	5.5 lbs.	5.25
18 V @ 10 Amps	10 lbs.	6.75
18 V @ 25 Amps	25 lbs.	14.95
18 V @ 50 Amps	30 lbs.	24.75
36 V @ 2.5 Amps	7.5 lbs.	5.25
36 V @ 5 Amps	10 lbs.	6.50
36 V @ 10 Amps	20 lbs.	10.95
36 V @ 25 Amps	30 lbs.	22.50

PRI—115 Volts—50/60 Cycles

Open Frame Construction

SEC—135/145/155/165 V @ .5 Amps	5 lbs.	$5.25
135/145/155/165 V @ 1.5 Amps	15 lbs.	7.95
135/145/155/165 V @ 2.5 Amps	25 lbs.	13.50
135/145/155/165 V @ 5 Amps	35 lbs.	24.50

HIGH VOLTAGE CAPACITORS

1 MFD 20 KV DC 18"x13½"x5"	$25.00
.1 MFD 25 KV DC-13"x7"x4"	9.85
.001 MFD 50 KV DC-5½"x7¼"x4" insulators 4" dia. x 7" high	12.50

Cap. Mfd.	Volts D.C	Height	Width	Length	Price
10	1000	5-7/8 x	1-3/4 x	3-7/8"	$1.85
4	1000	5-7/8 x	2-3/4 x	1-1/4"	.85
1	1000	3-5/7 x	2 x	1-1/16"	.50
1	500	2" x	1-1/4" x	1-1/16"	.25
.25	1000	1-1/2 x	1" x	3/4"	.25

HEINEMAN CIRCUIT BREAKER

For use with low voltage, D.C., 100 Amps Dimensions: 3¼"H x 4"D x 1" W..... $1.75

15 Amp, 115 V AC, Curve 3, CAT.AM 2511-15 $1.75

35 Amp, 120 V AC, Curve 2, CAT.AM 1510R-35 $1.75

1.5 Amp, 117.5 V AC, Instant Trip..... $1.75

WESTON Model 622—New!

D.C. Portables . . . ½ of 1% accuracy . . . High sensitivity . . . Moulded bakelite case . . . A famous instrument at a real low price.

0-20 Range	List	Your Price
0-30 Microamps— 280 ohms	$232.50	$139.50
0-30 Microamps—1800 ohms	202.50	121.50
0-50 Microamps— 150 ohms	217.50	130.50
0-10 Microamps— 90 ohms	210.00	126.00
0-2 0 Microamps— 45 ohms	210.00	126.00
0-100 Microamps— 10 ohms	210.00	126.00
0-.5 Mills Thermal	300.00	180.00
0-2 Mills Thermal	300.00	180.00
1.5/3/7.5/15/30/75 150/300/750 Volts	294.75	237.00

QUANTITIES LIMITED! ACT NOW!

WHSE PORTABLE GALVANOMETER

Type PX-12-7 M.A. movement, special scale, solid connecting terminals, contains a 1 volt internal cell which can be easily removed for conversion to DC AMMETERS & VOLTMETERS, with leather case & canvas carrying strap.

A buy at $4.95

GE TYPE DO 50 DC AMMETER

50 MV FULL SCALE, RECTAGULAR 3¼" x 3", Barrel 2¾" DIAM, x 1½" DEEP, MOUNTING HOLES 2⅝" x 2⅝" c. to c. SPECIAL SCALE, CAN BE USED WITH EXT. SHUNT FOR ANY RANGE, BAKELITE CASE

Price . . . . . 10 for $27.50

GE TYPE DO 50 DC VOLTMETER

3 VOLTS FULL SCALE, 100 OHMS 1V, SPECIAL SCALE, SAME DIMENSIONS AS ABOVE, BAKELITE CASE

Price . . . . . 10 for $27.50

MICROVOLTER—FERRIS Model 20B

.2 to 100,000 microvolts output, continuously variable . . . operates on 115 V. 60 cycle AC . . . push button selector for 15 frequencies from 455 K.C. to 22 M.C. . . . with or without 400 cycle 30% modulation . . . frequency may be varied ±2% by screwdriver adjustment.

Your Price $100.00

GE STEPDOWN TRANSFORMER

PRI 115/230 V 60 cycles.
SEC 32 V. Rating .5 KVA
Isolation type cat 61G60 enclosed, bell end, cont. duty.

Your Price $7.50

STEPDOWN TRANSFORMER—SPECIAL

Made by GE . . . heavy duty . . . considerable over-design . . . open frame . . . ideal for rectifier application . . . size 3½" x 3½" x 4". Primary—115 V 60 cycles.
SEC—15 V. @ 12 amps . . . a buy at $3.75
SEC—10 V. @ 18 amps . . . a buy at 3.75

POWER TRANSFORMER

Pri.—440/220 V 60 Cy Sec—125/115/105 V. Rating .8 KVA RCA Open construction. Bracket mounted, pri & sec terminal board. Overall dimensions: 5¾" H. x 7½" W. x 8" D. Mounting Dimensions 6⅞" x 5⅞".

Price $12.50

TRANSTAT—3 K.V.A.

Type RH Input: 115 V. 10%. Output: 115 V. Max. Amps: 26 A. Made as a line voltage corrector 10% of input voltage, or can be connected to give plus 20% or minus 20% of input. Can also be reconnected to be used as an isolated type stepdown with variable secondary. Input: 115 V. Output: 0-30 Volts at 30 Amps. No Knob.

A Real Buy at $18.00

(Same type but .25 KVA. Input: 103-126 V. Output: 115 V.-2.17 A.)

Price $6.50

RHEOSTAT

Ohms	Amps	Size-Diam.	Price
.87	13	3½"	$2.50
6	2	1½"	1.75
10	9.2	14"	5.95
22	4.5-3.1	6"	6.50
30	1.7- .9	2½"	1.50
32	2.4	3½"	4.95
40	1.12	2"	2.50
50	1.11	2"	2.50
75	3.5	6"	7.50
100	1	3"	2.95
200	.25	1½"	.75
250	2.5- .51	6"	7.50

STRUTHERS-DUNN RELAYS

D.P.S.T., Normally open, 115 V, 60 Cycle, AC coil, 30 Amp. contacts, fibre base with 4 holes for mounting. Dimensions, 4½" L x 3" W x 3¾" H.

A Real Buy At $2.50

ALL PRICES INDICATED ARE FOB OUR WAREHOUSE NYC. SHIPMENTS WILL BE MADE VIA RAILWAY EXPRESS UNLESS SUFFICIENT POSTAGE IS INCLUDED OR OTHER INSTRUCTIONS ISSUED. WE WILL REFUND EXCESS POSTAGE IN STAMPS.

POWERTRON Electrical Equipment Co.

117 LAFAYETTE STREET *Phone:* WOrth 4-8610 **NEW YORK 13, N. Y.**

BIG VALUES IN SURPLUS

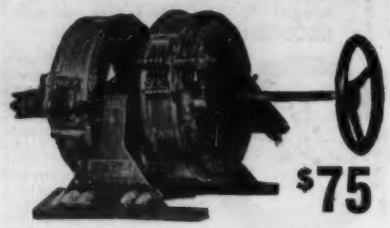
Inter-Communication Sets
Manufactured by Dictograph

Designed to bring to homes and offices the convenience of two-way conversation without the use of telephone, household electric current, or radio.

It can be set up in any two rooms you wish . . . being limited only by the length of the wire you use. Inter-Communication Sets will operate efficiently up to 800 feet using 14-gauge wire. Operates off three 1½ volt flashlight batteries per unit.

BRAND NEW, Pair **$9.95**

"TRANSTATS" *Amertran Voltage Regulator*



$75

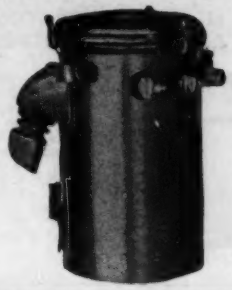
11.5 KVA: 50/60 cy. Commutator Range 0-115 V. Max. Amp. 100. Can be reconnected for 230 volts @ 50 Amps.

BRAND NEW

General Electric, Oil Filled OUTDOOR TRANSFORMERS

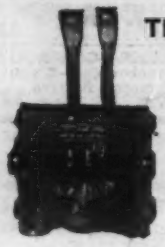
BRAND NEW

3 KVA: TYPE HS; 3000 5200Y-115/230 STYLE 3266596-G1; IN ORIGINAL FACTORY CASES



$36.

Heavy Duty TRANSFORMERS



Primary: 55 V. Secondary: 10 V @ 238 Amps., 2.38 KVA. Dimensions: 5½"x 7½"x8½".

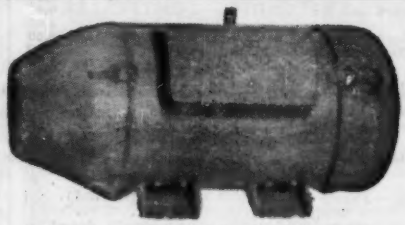
Two transformers can be put in series to operate on 110 V Input, giving secondary of 20 V, 238 Amps.

BRAND NEW INDIVIDUALLY CASED $12.50 each

2 units for $22.50

MOTOR GENERATORS

Built by Allis Chalmers to U. S. Navy Specifications



Input: 115 Volts, DC at 14 amperes. 3600 speed, ball bearings. Output: 1.25 KVA; 80% P.F.; 120 Volts, 10.4 Amperes. With resistive control of voltage output and frequency built-in and with Centrifugal automatic controller built-in, permitting line-start operation. Fully enclosed. Splashproof. Brand New in Original Factory Cases. **$100**

Same machine for 230 Volts, DC operation. **$120**

Spare parts kit of brushes, brushholders, ball bearings, field coils, etc. in steel case, **Price $10.**

Cotrell System PRECIPITATOR

Unit consists of very large screen for roof mounting and General Electric Transformer designated as "Substation Transformer" 13,200 Volts, 3 phase, 60 cy. Sec. 110/220V, 75 KVA, original cost $7,000.

Like New **PRICE $775.**

DUST COLLECTORS

These machines, manufactured by the Torit Mfg. Co. of St. Paul, Minn., are used for extraction of any dust from the air. They consist of a suction blower driven by a GE 1½ HP Motor; Type K; 220/440-3-60, 3475 RPM, and the entire unit is housed in a heavy steel case with louvres for dust intake.

PRICE $100.

General Electric Type IRT 3 PHASE INDUCTION VOLTAGE REGULATOR

1.64 KVA. Outdoor service, filled with 9 gallons oil. Primary Volts; 208; Load Amperes—10.5. Brand New and in original manufacturer's cases.

PRICE $83.50

MOTORS

General Electric Motors; Type B288; 6¾ HP; no base; flange mounting; 230 Volts, D.C.; Fields separately excited at 110 Volts. 1100 Speed; Ball Bearings. Brand New in original factory cases. **Price $64.50**

Electric Specialty Motors; Type BF51B; Marine Duty; Double Shaft, Ball Bearings; 2½ HP—5 Min. 440-3-60. Brand New in original factory cases. **Price $23.50**

General Electric Motors, 1/6HP, Type BC, 115 VDC, 1725 RPM Compound Wound. Reconditioned, guaranteed perfect. **Price $9.50**

TRANSFORMERS

West. Dist. Trans: Brand New complete with oil. Type S 2400/4160Y Volts to 120/240.

3 KVA **$50**

1½ KVA **$37.50**

Pennsylvania Air-Cooled Transformers. 10 KVA; Two insulated windings. 220/110 Volts. Brand New. A remarkable value at. **$65**

Westinghouse Air-Cooled Transformers—460/230-230/115 volts, 1½ KVA, Type JR. Brand New **$21.90**

Westinghouse Transformers—460/230-230/115 volts, 1 KVA. Air Cooled, Type JR. Brand New. **$17**

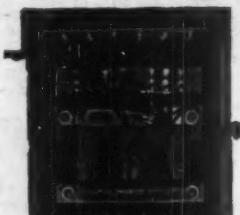
INVERTERS

Electronic Laboratories Inverters; Type 262; 250 watts, maximum; 110 volts, DC, input to deliver 110 Volts, AC, 60 cycles. Brand New but shop-worn—repainted. Guaranteed perfect. **Price $26.50**

ART Inverters; 6 Volts DC to deliver 110 Volts, AC; 85 watts, maximum. Brand new. **Price $14.50**

ATR Inverters; 6 Volts DC to deliver 110 Volts, AC; 85 watts maximum. Brand New. **Price $17.00**

G. E. Motor Starting Reactors



Type 11K2840G2

Rated at 440 Volts, 3 Phase, 60 Cycles, 16.8 Amperes. 15-20 HP. Waterproof Steel case. 17" x 15" x 10". Brand New in original factory cases.

$9.90

CONTINENTAL MOTOR GENERATOR SETS

7½ KVA; 1800 Speed, Ball Bearings. Input: 230 Volts, DC. Output: 115 Volts, AC, single phase, 60 cycles. Complete with automatic controller, field rheostat and push button station.

Rebuilt—same as new **PRICE $490**

Westinghouse Watthour Meters

Type CS, 240V/60cy/1ph 15 Amp., 3 Wire, new **$12.50**

Type CS, 120V/60cy/1ph 15 Amp., 2 Wire, new **$9.50**

Type CA, 120V/60cy/1ph 15 Amp., 2 Wire, new **$9.50**

Bendix Autosyn, Type AY-101-D; Input: 26 Volts, single ph. 400 cyc. 65 mils, .36 watts. Can be used on 6.3 volts, AC, 60 cycles, with current drain of 75 mils and .3 watts. **PRICE $21.50**

Ford Instrument Synchro Generators, Type 5G; MK 1 Mod. 3 115/90 Volts, 60 cyc. **PRICE $37.50**

Step-by-step Motors; 65 volts, complete with gear train. **PRICE $65.00**

Pioneer Autosyn Indicators, Type AY-1; 26 Volts, 400 cyc. **PRICE $4.50**

GE Selsyn 2J1G1; 57.5 Volts, 400 cyc. Two or more connected together work perfectly on 60 cyc. Connecting data included. **SPECIAL PRICE $2.50 PER PAIR**

GE Selsyn 2J1F1; same as above but operates on 115v/57.5 v. 400 cycles. **PRICE $3.00 PER PAIR**

DIEHL FP-25-3, 2 Phase, 60 cycles, low inertia motor. 20 volts per phase. 2.5 watts; 2 pole. Stall torque 2.5 oz/in. .35 amps. per phase; 1 oz/in. at 2700 RPM. **SPECIAL PRICE $8.75**

DIEHL FPE25-11 (Navy type CDA 211052) Low inertia Motor. 5 watts output; 75/115 Volts, 60 cycles, .11-.16 amps; 4.25 oz per inch, stall torque. Develops 65% of stall torque at 2000 RPM. **SPECIAL PRICE $15.00**

Ford Instrument Synchro Generator, 7G, MK111 Mod. 3 115/90 Volts 60 Cycles. **Price $16.50**

Arma Corp. Synchro Differential Generator, Type 5DG MK4 Mod. 1 90/90 Volts 60 Cycles **Price $7.95**

Diehl Synchro Transmitter, Type C78414 115 Volts 60 Cycles **Price $4.35**

Western Electric Motor, KS8624, 20 VAC, 200 Cps, 2 ph. 9000 RPM. **Price $4.95**

Oster Shunt Motor, Type E-7-5, 27½ Volts DC, 1/20 HP 3650 RPM. **Price $7.50**

Oster Series Motor, Type C-2BP-1A, 27.5 Volts DC, 1/100 HP 7000 RPM. **Price $2.50**

Universal Electric Shunt Motor, KS5603L02, 28 Volts, 6 Amps. 5000 RPM. **Price $2.00**

Elinco AC Generator, Type F-16 2 phase, 1.3 Volts per 100 RPM. **Price $7.95**

Elinco DC Generator, Type PM-2, 1.75 Volts per 100 RPM **Price $5.75**

Universal Electric Co., 115 VDC, 500 RPM, .12A **Price $4.50**

Emerson Electric Motor, Style 1610212, 24 Volts 160 oz/ft 27 Amps. 100 RPM. **Price $8.95**

G. E. Permanent Magnet Generator, 5BY9E8, 140 Volts DC .025 Amps, 1800 RPM. **Price $5.50**

G. E. Amplidyne, Mod. 5AM45DB20, input 115 Volts, single phase, 60 Cycle 5.0 Amps. output 250 Volts, 0.6 Amps. 150 watt, 3450 RPM, continuous duty **Price $53.50**

General Electric Automatic COMPENSATOR

Type CR7051-H1A; Cat. 4386997G8, 2200 Volts, 3 Phase, 60 Cycles; 75 H.P.; Control Voltage: 220.

Condition Like New **PRICE $365.**

IMPOSSIBLE TO LIST ALL OF OUR ITEMS AND COMPONENTS. TELL US YOUR NEEDS.

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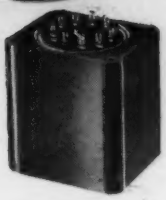
Electro Sales Company

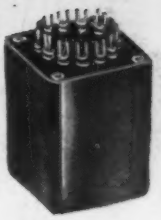
Dept. E-12, 110 Pearl Street, Boston 10, Mass.

COMPONENTS FOR EVERY APPLICATION



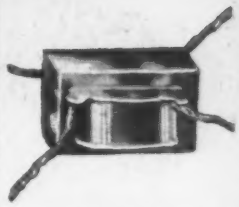
LINEAR STANDARD
High Fidelity Ideal

HIPERM ALLOY
High Fidelity . . . Compact



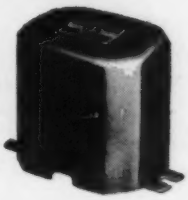
ULTRA COMPACT
Portable . . . High Fidelity

OUNCER
Wide Range . . . 1 ounce

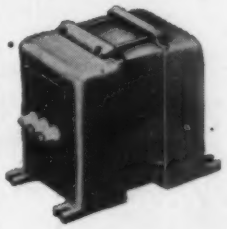


SUB OUNCER
Weight ⅓ ounce

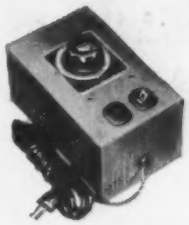
COMMERCIAL GRADE
Industrial Dependability



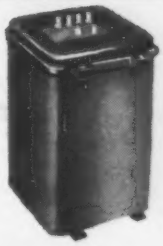
SPECIAL SERIES
Quality for the "Ham"



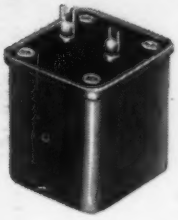
POWER COMPONENTS
Rugged . . . Dependable



VARITRAN
Voltage Adjustors



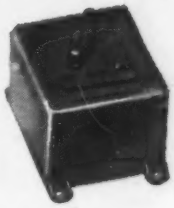
MODULATION UNITS
One watt to 100KW



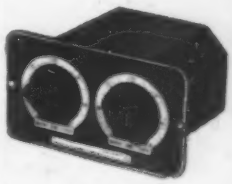
VARIABLE INDUCTOR
Adjust like a Trimmer

TOROID HIGH Q COILS
Accuracy . . . Stability

TOROID FILTERS
Any type to 300KC

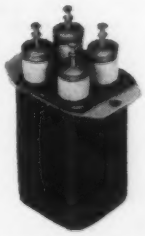


MU-CORE FILTERS
Any type ½ — 10,000 cyc.



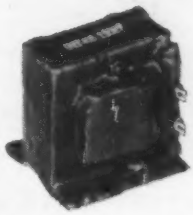
EQUALIZERS
Broadcast & Sound

PULSE TRANSFORMERS
For all Services

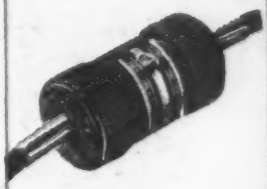


HERMETIC COMPONENTS
Ceramic Terminals

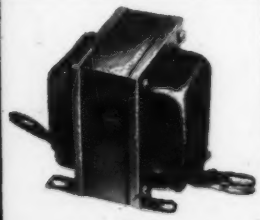
HERMETIC COMPONENTS
Glass Terminals



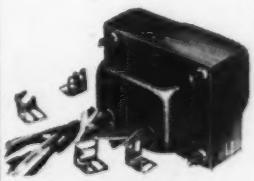
GRADE 3 JAN
Components



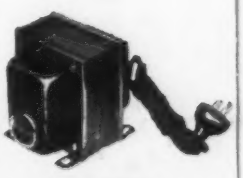
CABLE TYPE
For mike cable line



VERTICAL SHELLS
Husky . . . Inexpensive

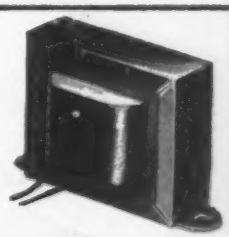


REPLACEMENT
Universal Mounting



STEP-DOWN
Up to 2500W . . . Stock

LINE ADJUSTORS
Match any line voltage



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Simple . . . Low cost

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Tubes for today and tomorrow

HERE ARE power tubes, phototubes, and c-r tubes to serve the major requirements of equipment manufacturers for a long time to come. The tubes listed are those you can depend on now, and for your future designs.

These RCA types are especially recommended because their wide-spread application permits production to be concentrated on fewer types. Such longer manufacturing runs reduce costs—lead to improved quality and greater uniformity. Resultant benefits are shared alike by the equipment manufacturer and his customers.

RCA Application Engineers are ready to suggest suitable tube types for your design requirements. For further information write RCA, Commercial Engineering, Section LR-40, Harrison, N. J.

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

Preferred List of RCA Non-Receiving Types

CATHODE-RAY TUBES AND CAMERA TUBES

Kinescopes (Projection)	Camera Types	Oscillograph Types	Monoscope
5TP4	5527	2BP1	2F21
	2P23	3KP1	
(Directly Viewed)	5655	5UP1	
7DP4	1850-A		
7JP4			
10BP4			

PHOTOTUBES

Gas Types	1P41	921	927	930
Vacuum Types	922	929		
Multiplier	931-A			

GAS TUBES

Thyratrons	2D21	3D22	884	2050	5563	
Ignitrons	5550	5551	5552	5553		
Rectifiers	3B25	673	816	857-B	866-A	869-B
	8008					
Voltage Regulators	0A2	0C3/VR105		0D3/VR150		

POWER AMPLIFIERS AND OSCILLATORS

(Air-Cooled)	TRIODES (Forced-Air-Cooled)	(Water-Cooled)
811	6C24	9C21
812-A	7C24	9C27
826	9C22	889-A
833-A	9C25	892
8000	889R-A	
8005	892-R	
8025-A	5588	
	5592	

TETRODES		BEAM TUBES	PENTODES
(Air-Cooled)	(Water-Cooled)	(Air-Cooled)	(Air-Cooled)
4-125A/4D21	8D21	2E24	802
		2E26	
		807	
		813	
		815	
		828	
		829-B	
		832-A	

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